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FIG. 16.—PLACING CHEESE CLOTH RETAINERS OVER NESTS CONTAINING BASS FRY ABOUT READY TO SWIM UP.

Most of the nests are seen covered with retainers. The retainers confine the fry for convenience in transferring to other ponds to make room for following broods. (Mammoth Spring station, Arkansas.)

FIG. 17.—POND DRAWN DOWN AND NEST BOXES PLACED FOR SPAWNING.

Area of pond, 55,000 square feet; 50 nests in pond; 150 breeding small-mouth black bass. (Mammoth Spring station, Arkansas.)

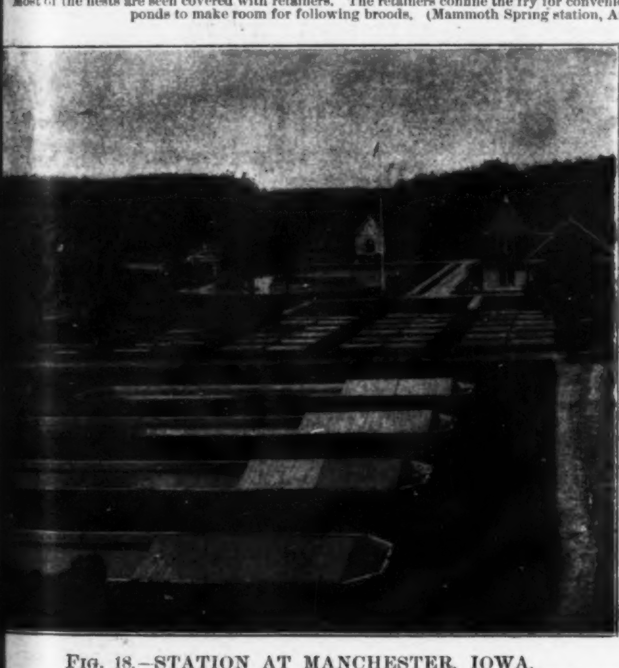


FIG. 18.—STATION AT MANCHESTER, IOWA.

...ows stock ponds in foreground, then the smaller nursery ponds, all of these for trout and built ...ement. Beyond, in front of the hatchery building, is a bass pond with earth bottom and sides.

FIG. 19.—PREPARING A SHIPMENT OF SMALL-MOUTH BASS.

Tanks used for hardening the young fish prior to transportation. (Mammoth Spring station, Arkansas.)

...G. 20.—MAIN RACK ACROSS BATTLE CREEK NEAR THE BATTLE CREEK STATION, CALIFORNIA.

Upper sections of rack raised to facilitate disposal of leaves and other debris.

FIG. 21.—SEINING SPAWNING SALMON ON THE McCLOUD RIVER, CALIFORNIA, AT THE BAIRD STATION.

Steam power has now replaced the hand windlass.

HOW FISH ARE HATCHED.

HOW FISH ARE HATCHED.—III.

FISH-CULTURAL PRACTICES IN THE UNITED STATES BUREAU OF FISHERIES.

BY JOHN W. TITCOMB, ASSISTANT IN CHARGE OF THE DIVISION OF FISH CULTURE.

Continued from Supplement No. 1809, Page 165.

ARTIFICIAL NESTS.

In the cultivation of the small-mouth bass, and to some extent the other species, it has been found profitable to provide artificial nests. These are of various design, but embody in general some sort of a container for the gravel the fish require, together with a shield or screen on two or three sides. The primary use of screens was for the purpose of shielding the fish from view of passers-by, but the practice resulted in the discovery that the fish will accept shielded nests at more frequent intervals than when visible to each other. It is therefore of first importance that in the placing of nests the screens be arranged to meet this condition.

When shielded artificial nests are not provided it is customary to deposit here and there in the ponds mounds of coarse gravel, 18 inches to 2 feet in diameter and about 6 inches in height, so that the breeders may select and prepare their nests with these.

Large-mouth black bass, though they sometimes accept gravel mounds as nests, naturally seek a weedy bottom, devoid of gravel. Peat-like sods or similar substances put into the pond prove acceptable to this species as nesting material.

The superintendent of the Cold Springs, Ga., station endeavors to imitate nature by providing "homes" for with 24 to 30 large-mouth bass to the half acre; of the smaller fishes—bream, rock bass, crappie—60 to the half acre.

A one-acre pond at Mammoth Spring, Ark., supports 100 small-mouth black bass, and an average of 2,000 fry to each productive nest has been obtained, the maximum number from one nest being 5,200.

At Cold Springs, Ga., 100 adult large-mouth black bass in a pond of three-fifths of an acre in area proved too many, and the number had to be reduced to 60 or 70 for satisfactory results. In general, 50 to 75 brood bass to three-fourths of an acre or an acre have been found the best number at this station. Of catfish (*Ameiurus nebulosus marmoratus*), 100 to the acre have been found satisfactory.

Ponds at Wytheville, Va., accommodate 75 pairs of large-mouth black bass to the acre with good results; of rock bass, 300 fish to the acre.

At Northville, Mich., in a pond three-fifths of an acre in area it has been observed that most satisfactory results were obtained with small-mouth bass to the number of 29 females and 23 males, allowance being made for the occasional polygamous tendency of the male.

At White Sulphur Springs, W. Va., 36 pairs of small-water to effect their capture, it is necessary to remove the aquatic vegetation, a process of much labor and expense, consisting in general of mowing under water and carrying away the foliage by means of pitchforks and boats. Various methods and devices for this purpose have been evolved at the different stations, as described elsewhere.*

Ordinarily the assorting of young pond fishes by size is accomplished by hand manipulation with a scaff net. To some extent, however, the separation may be accomplished by regulating the size of the mesh in the nets used to effect their capture. The superintendent of the San Marcos, Tex., station suggests having an ample bag to the dip net in which quite a large lot of fish may be taken from the tub or other retainer, then passing the net gently to and fro in the water to allow the fry and smaller fish to escape, while the larger ones are retained. This method is principally used for assorting black bass, as it frequently happens there are schools of both fry and fingerlings in the ponds at the same time. Nets of one-fourth inch square mesh will permit the escape of all fish up to 1½ inches; one-half inch square mesh will permit the escape of all fish under 3 inches in length.

At the Cold Springs, Ga., station the superintendent uses a box 3 or 4 feet long by 1 foot wide and 1 foot deep, and water-tight to a depth of 2 inches. Above this 2 inches one side is covered with wire cloth instead of being closed in, the size of wire mesh being regulated for known sizes of fish. The box is partially submerged in the pond in which it is intended to place the smaller fish of a lot to be assorted. The young fish as caught are placed in the box, and then are left undisturbed for an hour or two. At the end of this time the smaller fish will have escaped from the box through the screen into the pond, when the box with the larger fish remaining in it may be transferred to another pond and emptied, or the contents may be poured into a suitable receptacle for transportation by tipping the box toward its solid side. Square-meshed galvanized cloth is used for the screen, and if the fish are given plenty of time to separate none of them are gilled, hung, or otherwise injured.

FIG. 22.—SPAWN-TAKING OPERATIONS, BAIRD, CAL.

The fish (Chinook salmon) are dipped from the pen, killed by a blow on the head, and passed to the spawntakers. The eggs are taken by opening the abdomen, and stream of eggs may be seen in picture following the hand making incision.

FIG. 23.—ONE METHOD OF STRIPPING STEELHEAD TROUT.

Since this fish normally does not die after spawning, ripe fish are not killed as are salmon, and they are so large and so powerful in their struggles, that strait jacket here shown is sometimes resorted to.

all adult fishes whether spawning or not. For the large-mouth black bass and rock bass, boards 3 feet to 10 feet in length are laid flat under the water so that by the natural contour of the bottom spaces 5 inches to 8 inches deep are formed under the boards. Catfish (*Ameiurus nebulosus*), which prefer to dig their own nests, are provided with boards either laid flat on the pond bottom or where there will be under the center of the board a depression an inch or two in depth. Where necessary, the boards are fastened by stakes at both ends; but when placed along the bank, where conditions are favorable for such a course, one end of the board may be driven a short distance into the embankment, while the other end is staked. After having been submerged a month or so the boards will remain in place without fastening. With proper precautions against projections these shelters do not materially interfere with seining operations.

For the crappie, roily water seems to be essential during the spawning season. At stations where there are no naturally roily ponds it has sometimes been found desirable to introduce a few carp, which roil the water in rooting around the bottom of the pond and do not seem to disturb the crappie.

NUMBER OF BROOD FISH.

The desirability of maintaining a maximum number of brood fish to a given pond area has led to a comparison of experience at the different stations in an effort to arrive at some approximate average for a working basis. Conclusive determination can be made, of course, owing to the various factors of quality and temperature of water, abundance of vegetation and of natural food, etc., but reports from the several localities are of interest.

At San Marcos, Tex., the best results are obtained mouth black bass is considered the number for a one-acre pond.

The maintenance of an abnormally large number of brood fish to a given area results in more or less loss according to species, the mortality among the brood fish of the small-mouth black bass being greater than with the large-mouth bass and other pond fishes. The replenishing of the stock is most advantageously accomplished by securing wild fish, preferably in the spring of the year, and they may be advantageously transferred up to within two or three weeks of the spawning season.

COLLECTING THE YOUNG FISH.

It is often desirable to remove the surplus fry from a pond before they have left their nests, and there is now in use for this purpose a combination fry trap and retainer which is placed over the nests, taking advantage of the fact that the fry rise vertically. This trap has proved of practical value in fish-cultural ponds for small-mouth bass, and, where the nest area was not too great, for large-mouth also. It has been used likewise in collecting small-mouth bass fry from natural lakes, and is believed to be applicable to fry of other nest-building fishes than the basses.

Soon after the yolk sac has been absorbed, or after the fry have been feeding for two or three weeks, a portion of them are removed from the ponds and distributed to the waters they are to stock. The first crop may often be obtained by seining around the edges of the pond without the preliminary clearing away of vegetation, and for this purpose a novel casting seine has come into use at Northville, Mich. The web is rigged upon two long bamboo poles, so that the device may be operated entirely from shore, without roiling the water or unduly disturbing the fish.

After the young fish have sought the deeper portions of the ponds, preliminary to drawing off the

RESCUE OF FISHES FROM OVERFLOWED LANDS.

In the upper Mississippi and Illinois rivers there is an annual spring flood period caused by the melting of the snow in the northern forests and freshets in the local tributaries after heavy rains. The period begins with the approach of warm weather, usually about March 15th, and continues until about June 1st, when the crest of the high water has been reached. Soon after this date the water begins slowly to recede, and usually by July 15th the river has reached its normal stage.

Between the extreme low and high water marks there is a variation of 12 or 15 feet. There is, of course, a variation in the extremes of the water level in different seasons, but seldom, if ever, does the water fail to rise high enough to flood the lowlands. The adult fishes are thus permitted to enter the overflow

* Address before the Fourth International Fishery Congress, held at Washington, D. C., September, 1908.

* Titcomb, J. W.: Aquatic plants in pond culture, Bureau of Fisheries Document 643, 1909.

basins and bayous, and invariably do so dur'ng the spawning season. After spawning most of the adult fish escape to the river before the water has receded sufficiently to cause them to be hemmed in, but immense numbers of their progeny are left in the [illegible]s and bayous where they were hatched. These waters gradually dry up, become choked with vegetation, or overheated and unfit for fish life; some of the larger and deeper lakes and bayous, although cut off from the main river, may contain water the year around, but on account of the seepage and evaporation during the summer the depth of water in them decreases to such an extent that they freeze solid during the winter months. Sometimes the lakes from which fishes are rescued are in the hollows on farm lands, where in dry seasons crops are cultivated. Thus it will be seen that the fish imprisoned in overflow water are doomed to destruction in one way or another.

One branch of the Bureau's operations is annually to rescue large numbers of these fishes. At present the work is confined to waters convenient of access—namely, the overflow lakes and bayous on the low islands in the rivers and on the adjacent mainland. Many of the fishes are returned to the rivers. Another portion of the more desirable species is distributed in various other waters, often far from the source of supply.

It has been found, however, that the fishes rescued from these warm waters do not bear transportation long distances without heavy losses if immediately started upon their journey. Therefore a hardening process is resorted to, which consists in holding the fish in large tanks flowing through which are streams of clear cool water. To facilitate the work the Bureau has a number of field stations—one on the Illinois River and three on the Mississippi—convenient of access to the railroad, and each equipped for holding one or more carloads of fishes for several days, or until they have become sufficiently hardened to bear transportation by cars. Adjunct to these stations are vessels, launches, and boats of various types suited to the work.

By this means not only is a conservation effected, but the Bureau is enabled to meet the great demand of applicants for the basses, sunfishes, and perches at a less sum than it would cost to produce them at a station maintained especially for their propagation.

THE PACIFIC SALMONS.

On the Pacific coast the Bureau has six permanent stations, including two in Alaska, all of them maintained primarily for the propagation of the Pacific salmons. Subsidiary to these there are six important field stations and other smaller ones where salmon eggs are collected and hatched. An idea of the extent of the work may be obtained from a statement of the output of these stations during the fiscal year 1908.

Output of the Pacific Salmons in 1908.

Stations.	Species.	Eggs.	Fry and fingerlings.
Alaska	Sockeye	....	61,369,000
California	Chinook	64,990,550	4,780,855
Oregon	Chinook	3,530,000	19,718,996
	Silver	....	215,932
Washington	Chinook	....	498,309
	Silver	296,000	13,262,714
	Sockeye	75,000	8,514,305
	Humpback	502,000	6,764,762

The eggs shown in this table were transferred to state fish hatcheries and other places for incubation. In California, as will be noted, a very large proportion of the eggs taken are so distributed.

Observations at various field stations indicate that a large percentage of salmon eggs deposited naturally are fertilized, but for various reasons only a small percentage hatch. Modern fish-culture methods permit of a much higher percentage of impregnation than under natural conditions, it being possible to actually hatch and distribute as fry more than 95 per cent of all eggs collected. So long, therefore, as a proper number of salmon are permitted to escape the various fishing devices in their ascent to the natural spawning grounds, and it is possible to capture them for the purpose of obtaining and impregnating their eggs, perpetuation of the salmon fishery is assured.

In the culture of the Pacific salmon it is impossible to save eggs from the commercial catch, because the latter is made before the fish are ripe, and to retain them until ripe is not feasible. By the time they have ascended the rivers to the spawning grounds and are in condition for the fish culturist the flesh has so deteriorated in quality that they are unfit for market in any form. The Bureau must therefore itself capture the fish it requires, and this is usually done by the construction of barricades to intercept the run at the most suitable point below the spawning grounds.

Barricades and Traps to Intercept Spawning Runs.

That successful work at the salmon stations depends largely upon stable and suitable barricades, or racks, as they are more commonly called, may be instanced by the resuts of the work at Battle Creek, Cal., in 1903 and 1904. At the height of the season in 1903 a freshet carried away several sections of the rack grating, permitting the fish to escape upstream.* As a consequence only about 27,000,000 eggs were secured. The following season no flood occurred at Battle Creek until near the end of the spawning season, and the collections that year numbered over 57,000,000 eggs.

As all the streams are subject to freshets, the water in some instances rising over 20 feet, the racks must be firmly built, and their successful operation depends not only upon ingenuity in construction, but the care that is taken to guard against their becoming clogged with leaves and other débris in times of flood—work which at times is exceedingly hazardous. Methods in the construction of racks vary with local conditions, as do also the methods of capturing the salmon thus intercepted.

At the Mill Creek station, in lieu of a main or upper rack, the Bureau is able to take advantage of a mill dam 12 feet high, which effectively stops the passage of salmon. Half a mile below this dam a retaining rack with the usual traps prevents the fish from dropping down stream. Seining and spawning operations are conducted on the streams between the dam and the retaining rack.

At Baird, Cal.—At the Baird station on the McCloud River in California are two racks or barriers between which is formed a pool 400 feet in length. The upper rack intercepts the further passage of salmon, and the lower or retaining rack gives the fish free entrance to the pool, but effectually prevents their return. The upper rack reaches across the river, a distance of 250 feet, and is primarily supported by ten concrete piers averaging 8 feet in height and extending 5 feet above low-water mark. The piers are properly fastened to the bed rock of the river bottom by means of heavy iron bolts. They have a flat top 4 feet wide and 6 feet long, and from top to bottom is a beveled nose extending upstream at an angle of 60 degrees, making them 4 feet wide and 10 feet long at the bottom. On either bank a small crib pier filled with rock supports the shore ends of two 10 by 10-inch stringers laid parallel from shore to shore across the tops of the piers. A 2-foot walk is built between the stringers and the whole is securely wired to eyebolts built in the pier tops.

Across the river bottom, against the nose of the piers, is a 10-inch sill. At intervals of 3 feet, poles 4 inches in diameter extend at an angle of 60 deg. from the sill at the bottom to the stringer at the top, and are securely fastened to the latter by large spikes. Against these poles or inclined uprights rest the gratings of the rack, which for the sake of convenience in handling are built in sections 6 feet wide and from 6 to 10 feet long to suit the varying depth of water. The gratings are made of 1½ by 3½ inch slats of dressed lumber set 1½ inches apart, their thin edge facing the current, the edge being convex to facilitate cleaning and to permit the passage of leaves. The ends of the gratings are nailed between two pieces of 1½ by 4 inch material, notched into the slats to make a flush surface. The space between the slats is gaged by nailing on 1½ by 4 inch blocks to each end. The longer gratings are braced with two strips 1½ by 4 inches nailed on 3 feet from the bottom.

In the upper rack is placed a trap 10 feet square with vertical slat sides similar to the rack gratings and having a solid board bottom. The narrow opening which allows the fish to enter is so constructed as to reduce to a minimum their chance of escape. The trap is primarily used for observing the general condition of the fish in the pool prior to the beginning of seining or spawning operations.

The retaining rack is at the lower end of the pool, where the stream narrows to about 190 feet. It is supported on six stone-ballasted crib piers with sides 14 feet long, made by spiking together logs 8 to 12 inches in diameter until the required height is reached. The piers are built on shore, floated into place, and filled with rock. Across the upstream end of each pier are two 10 by 10 inch stringers laid parallel and supporting a board walk, as in the upper rack. Two small temporary piers are also built to support the shore ends of the rack. Gratings having 2-inch interstices are placed across the stream, similar to those in the upper rack, with the exception that five openings 2 feet wide are left between the piers nearest the center of the stream. These openings are covered by the usual traps, which extend upstream into the pool 9½ feet. The traps are 4 feet in height and 6 feet in width at the entrance, being shaped to fit the slant of the gratings. The sides are of 1¼ by 4-inch material spaced 2 inches apart, and with the broad edge toward the current. Braces are placed across the top, and at the apex of the trap is an opening 3 inches in width from the surface of the water to the bottom. The salmon pass into the pool through this opening and rarely, if ever, find their way out.

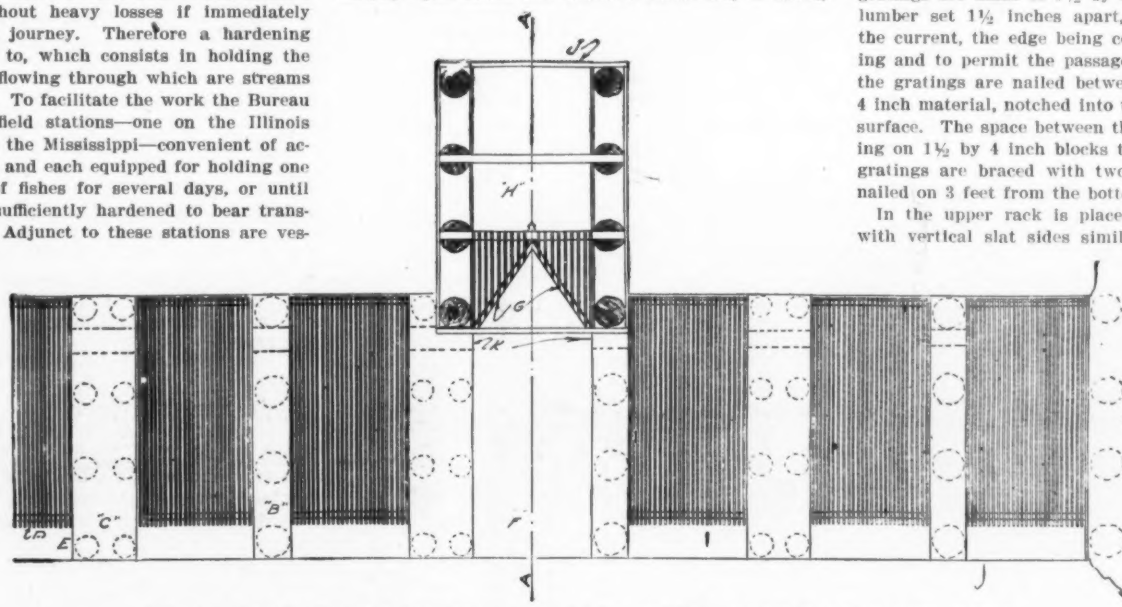


FIG. 24.—PLAN OF BARRICADE IN PHINNEY CREEK, NEAR BIRDSVIEW, WASH.

B and *C*, single and double rows of piles respectively; *D*, downstream end of racks; *E*, floor under racks; *F*, open channel to trap; *G*, walls of V-shaped approach to trap; *H*, trap; *J*, screen at head of trap; *K*, openings in pier for passage of fish to *G*; *L*, door in north side of V-shaped approach; *M*, abutments.

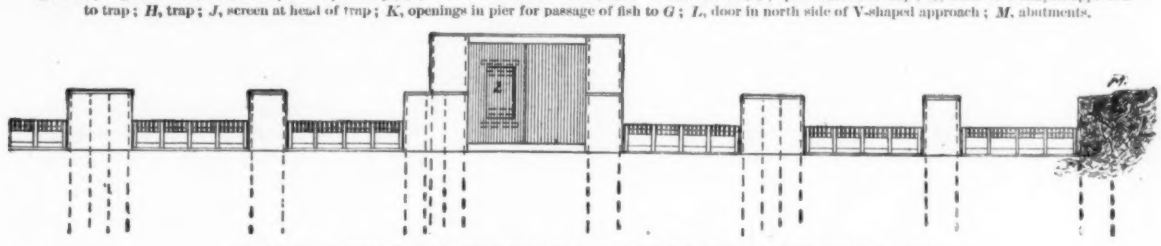


FIG. 25.—FRONT ELEVATION OF BARRICADE SHOWN IN FIG. 24.

* At Battle Creek the low-water mark is 10 feet below the top of the stringers on the rack, and during a recent flood the water was 12 feet above the top, making a 22-foot rise.

Before the installation of the retaining rack, some ten years ago, many eggs could not be collected by reason of the loss of fish from their running back downstream. This violation of the natural instinct of salmon to work ever upstream was due to fright resulting from the continual sweeping of the seine just below the upper rack. In the early days Indians were engaged to walk on either shore for a mile or so below the rack and beat the water with brush in an endeavor to drive the fish up to the seining ground. Since the installation of the retaining rack such measures have been entirely unnecessary.

At Battle Creek, Cal.—The main or upper rack at Battle Creek, Cal., is constructed on a comparatively soft and shifty river bottom, and is supported by piling, instead of by the log cribs anchored with rocks, more generally used. There are 12 bents of piling, each bent consisting of 3 piles driven firmly and braced with heavy timbers. The three piles comprising a bent are driven parallel with the current, the front one standing some 2 feet above low-water mark and the others about 8 feet above. The front and rear piles are placed about 10 feet apart. On these bents of piling and reaching across the stream are placed three 12 by 12-inch stringers, against which are secured 4 by 4-inch slanting supports, about 6 feet apart, the lower ends of which rest on a mud sill placed in the bottom of the stream. Stringers and these supports are so placed that the face of the rack will meet the current of the stream at an angle of about 60 deg. The gratings of the rack are built in sections of varying length but of a uniform width of 5½ feet. The slats for these gratings are of dressed lumber 1 by 3 inches, the side set parallel with the current, the upstream edge convex. At either side of the stream, in the shallower water, single sections of gratings about 10 feet long extend from the bottom to the top stringer. In the deeper portions of the stream two 6 or 8-foot sections of the gratings are used, one above the other, with an opening between the upper and lower sections for convenience during the lower stages of water in the removal, with rakes and hooks, of rubbish and trash drifting downstream. When the water rises the closing of this aperture is easily accomplished by knocking out the blocking between the two, thus permitting the upper rack to slide down flush with the upper edge of the lower section. The length of the rack from shore to shore is about 300 feet, its vertical height above low-water mark being about 8 feet. During low water the front is submerged to a depth of from 18 inches to 2 feet, but there are holes considerably deeper behind the rack. A walk 2 feet wide is built on the top of the rack. A half mile below the barrier is a retaining rack quite similar to the one described for the Baird station.

At Battle Creek the racks are usually installed during September in time to intercept the fall run of salmon, and unless carried out by high water, remain until the close of the work in December. Gratings, stringers, etc., are then removed and stored for use another season.

At Birdsview, Wash.—A permanent barrier at the Birdsview station, an auxiliary of the Baker Lake station, in Washington, is of novel construction and calls for more than passing notice. This barrier is located in a portion of Phinney Creek, where formerly there was a dam built for the purpose of obstructing the passage of steel-head trout. When the dam washed out a new channel formed and the river bed was very much broadened.

The first step in the construction of the new barrier was the laying of four heavy log stringers across this new channel from the abutment on the north to the new bank on the south side of the stream. The logs were let down through the dam foundation to low-water level on the north side and the deep channel under them on the south side was filled with brush and gravel. The logs were spotted down to form a practically level bed, reaching the width of the stream. Heavy piles were then driven behind each stringer to form alternate single and double rows extending up and down stream. The log stringers were next planked over, forming a platform 18 feet wide, similar to a regular dam apron, extending from the north abutment to the final row of piles on the south side, a distance of about 140 feet.

By planking the sides of the single rows of piles and all around the double rows and filling the space with rocks, piers 4 feet high and approximately 2 feet and 4 feet wide were formed. Through each pier at the bottom, behind the upstream pile, openings 1 foot square were left, connecting the spaces between the piers. These spaces, 12 in number, are approximately 8 feet wide and are filled by swinging gates hinged to a 3 by 12-inch timber, spiked securely to the piers on either side and forming a dam or flashboard across the space above. By the insertion of other flashboards above this one a tight dam 4 feet high can be quickly formed at any time. The utility of this feature will be explained elsewhere.

The gates are made of 1 by 4-inch fir, set on edge and nailed to 2 by 4-inch joist, being strengthened by 2-inch blocks set between the rack bars and nailed to them and the joists. These blocks thus determine the width of the interstices in the gates. At the upper end of each gate an auger hole is bored through the bars and blocks, to accommodate a 2-inch iron pipe, which passes through the entire upper end of the gates. Ringbolts clasp these pipes and are fastened to the 3 by 12-inch timber forming the flashboard, acting as hinges upon which the gates swing. At the lower end of each gate a wide board, 1¼ by 16 inches, is secured by means of braces, forming an angle of 45 deg. with the lower end of the gate.

At any ordinary stage of the stream the downstream ends of the gates rest on supports which hold them a foot or more higher than the upper ends, the water passing down through them to the floor of the apron, where it runs away. The fish working up under the gates to the dam board find the cross passages through the front end of the piers and finally reach the trap. It was expected that during freshets the current acting on the flashboard would always keep the lower ends of the gates above the surface of the water, and up to a certain point this expectation was realized, but at very high stages of the stream the large quantity of gravel in the water soon clogs and sinks the gates. As the gates are only two-thirds the length of the apron, however, and rise toward the lower end, the water shoots over them with such force that it is projected some distance below the end of the apron, and fish attempting to scale the obstruction fall far short of the ends of the gates. The barrier has been watched many times when fish were jumping and when the largest drift ran clear, and none has ever been seen to pass it.

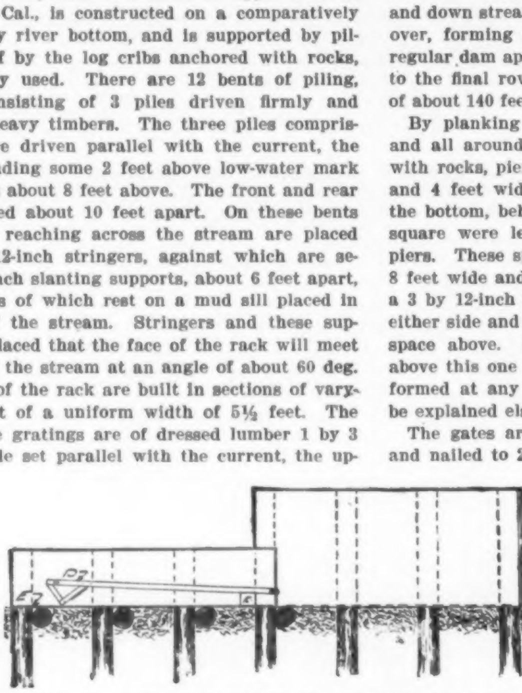


FIG. 26. SIDE ELEVATION OF BARRICADE SHOWN IN FIGS. 24 AND 25.

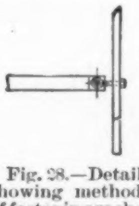


Fig. 28.—Detail showing method of fastening racks (see Figs. 24 and 26 D.)

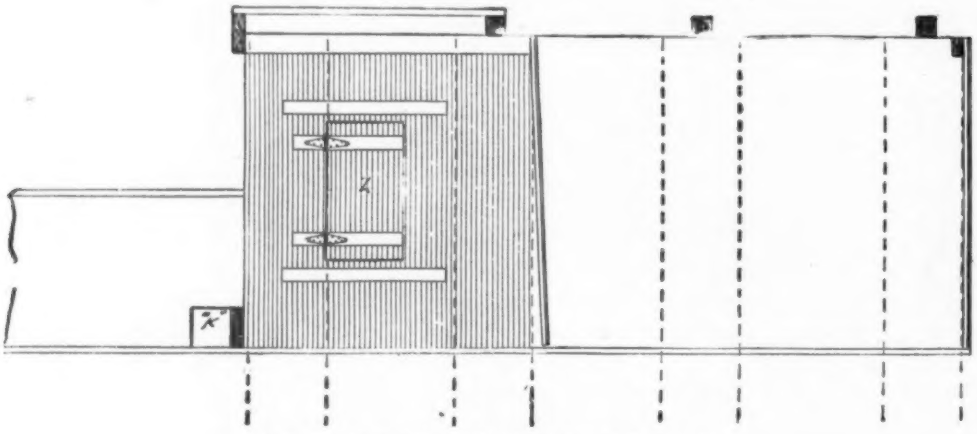


FIG. 27.—SECTION ON LINE A-A OF FIG. 24.

By means of the dam boards entire control of the current can be had during ordinary stages of water and any desired quantity sent to any section of the barrier. Thus a strong current can be maintained through the trap section, leading the fish to it, and when it is desired to remove the fish from the trap the water can practically all be turned to some other section of the barrier.

One of the greatest difficulties in maintaining traps in the streams in this section is due to the tremendous quantities of gravel carried in the water during freshets, a sufficient amount being frequently deposited in front of a trap at such times to change the course of the stream. With the present form of barrier no trouble is experienced from this source, the insertion of the dam boards and the opening of one space at a time quickly clearing away the accumulated gravel.

The ninth and tenth piers were continued upstream by driving three additional piles above each. The piers form the sides of the trap. Its floor is a plank bottom, similar in construction to the apron, and the front is barred by 1¾-inch pickets placed 1¾ inches apart, the fish entering by the usual upstream V of pickets. To protect the trap from high water the two piers between which it is located were carried to a height of 8 feet. When it is desired to fish the trap the gate at its head is closed and entrance is made from below by means of a door in the north side of the V.

The upper end of the fishway of the old dam was left in place, the narrow passage between it and the new trap protecting the spaces at the south end of the barrier from the current and from drift. These spaces have been racked above and below to form commodious pens for males and unripe females. The south end of the barrier is protected by a substantial abutment.

The maintenance or racks in Phinney Creek has been a very heavy item of expense in past years, and the trap was frequently carried away by freshets just at the height of the season, allowing large numbers of fish to escape and considerably reducing the season's take of eggs. It is believed the new barrier will stand any possible test that may be put upon it and will fish successfully in almost any stage of water. The design is to be credited to Mr. A. H. Dinsmore, superintendent of the station.

(To be continued.)

THE FLOW OF MARBLE.

IN a recent number of the American Journal of Science Messrs. F. D. Adams and E. G. Coker discuss their experiments on the flow of marble. The paper contains the results obtained by a study of the flow of marble under widely varied conditions of pressure, temperature, and time. The investigation was extended to a number of fine-grained and more or less impure limestones; to crystalline dolomites; and then to a series of typical plutonic intrusives—diabase, essexite, and granite. Experiments were made to measure accurately the loads required for the deformation of standard columns of these and other rocks.

The apparatus employed for testing was a heavy tube of steel, accurately bored out, into which fitted a very accurately turned or ground specimen of the rock. Pistons of hardened chromium-tungsten steel were inserted in the ends of the tube. A great lateral resistance was thus obtained, and its value could be varied by altering the thickness of the walls of the tube. The rock columns used for experiments were in most cases about 0.814 inch diameter and 1.56 inches long. High temperatures, up to 1,000 deg. C., were used and a special stove was devised.

The following conclusions were arrived at as a result of the experiments: (1) Marble, when deformed at ordinary temperatures, will flow readily by distortion of the original calcite grains, accompanied, if the differential resistance be low, with the development of a certain amount of cataclastic structure. (2) The marble, when deformed at ordinary temperatures, will increase in strength if allowed to rest. (3) The marble, if deformed at ordinary temperatures, will be much stronger if the deformation be carried on slowly than if the deformation be rapid. There is reason to believe that with the extreme slowness of deformation to which the rock is subjected in nature, and the long rest it subsequently undergoes, the change in shape would be accomplished without any loss in strength. (4) If the deformation be carried on at a higher temperature, the calcite develops freer movement on its gliding planes, and the deformed rock will be relatively stronger than if deformed at the ordinary temperature. (5) Under the conditions to which the rock was subjected in these experiments—although not under all conditions—the presence of water has no recognizable influence on the character of the deformation. (6) The specific gravity of the rock was not increased by the pressure to which it was subjected during deformation. In the arrangement of the apparatus the chief object was to reproduce, more or less accurately, the conditions of pressure which obtain in the deeper part of the earth's crust.

GAS DRIVEN SHIPS.

MARINE SUCTION PRODUCER ENGINES ON THE RIVER RHINE.

The Otto Gas Engine Works first tried a producer-gas engine for propelling boats in 1901. A number of canal boats with engines as large as 45 actual horse-power were sold by the German factory. On account of the considerable space occupied by the producer plants as then built, the business grew very slowly. Gasoline and kerosene engines almost monopolized the field. The successful operation of the marine producer-gas engines on canal boats, however, indicates that there are possibilities in the use of such plants on larger towboats or tugs. Several other firms who subsequently built such plants had poor success because they failed to realize the peculiar requirements, and did not adapt their equipment to marine service.

With the further development of producers, it became possible in those of the double-fire type to utilize brown coal briquettes as well as anthracite, and as these briquettes can be obtained cheaply anywhere on the Rhine, the economical operation of larger boats with producer equipment became possible. After making a most careful estimate of the cost and conditions of operation, the Otto Gas Engine Works found that the brown coal producer plant had a decided commercial superiority over steam, and the company decided to construct such a boat. Accordingly the tug "Deutz" was equipped with a 500 indicated horse-power gas-engine plant in place of a 300 indicated horse-power steam plant. This required a lengthening of about 10 feet. Its present measurements with 30 tons of briquettes on board are: Over all length, 112 feet; greatest width, 20 feet; depth at bow, 5½ feet; depth at stern, 6 feet.

The stack was retained to provide free outlet for the exhaust.

The whole machinery layout, shown in the illustration, occupies a space 20 feet by 42 feet. The producer room is separated from the engine room by a partition provided with a sliding door. It contains the producer, the gas-cleaning apparatus, and the coal bunkers. The producer is of the double-fire type, all the volatile matter in the fuel must pass through the upper fire zone before it reaches the gas outlet. This makes the gas practically tar free.

The cleaning apparatus consists of two separate units, capable of independent operation. After passing through a small scrubber with a spray at the top, the gas enters the main scrubber, which is provided with eight spray heads, one above the other, and each removable while running. From the main scrubber the gas passes to a centrifugal washer, driven from the main shaft, and provided with suitable water sprays. The gas next passes through a water separator. The two scrubber units have a single pipe leading thence to the gas receiver and then to the engine.

There are two four-cylinder 250 horse-power engines, each driving a 5-foot propeller through a reverse gear. The engine speed can be controlled between the limits of 90 R.P.M. to 200 R.P.M. from the engine platform. While maneuvering and taking up tows, one engineer and helper operate the machinery. The helper relieves the engineer during part of the long 16 to 18-hour day. The gas engine and reverse gear are so well adapted to the difficult service in maneuvering, that the operation is quicker and more certain than with a steam engine.

In the free part of the engine room are two pumps, one for delivering cooling water and scrubber water, and another for pumping waste water from a pump under the scrubber. On the aft port side of the engine room a 7 horse-power auxiliary gasoline engine is placed. This engine drives the compressor of the air starting equipment, and the exhauster for fanning the fire in the producer. By the use of a special belt it can be pressed into the service of raising the anchor, and also for pumping out. In regular operation the latter is done by the drainage pumps, which are provided with special suction piping for this purpose.

After the regular lay-over of six to eight hours the plant can be put in operation again in a quarter hour with absolute certainty. The construction of each cylinder as a separate unit has much to do with this success.

The following table gives the weight of the machinery parts in pounds per indicated horse-power:

Engine, flywheel, and reverse gear	158
Producer, lining, scrubber, and water in apparatus	189
Pumps, auxiliary engine, and other parts	15½
Piping	13¼
Fuel in producer	13¼
Total	389

The weight of the producer plant could now be made considerably less than this.

The weight of a triple-expansion steam engine of the same indicated horse-power would be:

Engine	198
Boiler	176
Auxiliaries and piping	60
Water in boiler	62
Total	496

Which is a fair average weight.

It therefore appears that the marine producer-gas engine plant is 20 per cent lighter than a steam plant of the same indicated horse-power. Further, the steam plant requires considerably more room. The cost of the gas engine plant is about 10 per cent greater than that of the steam plant.

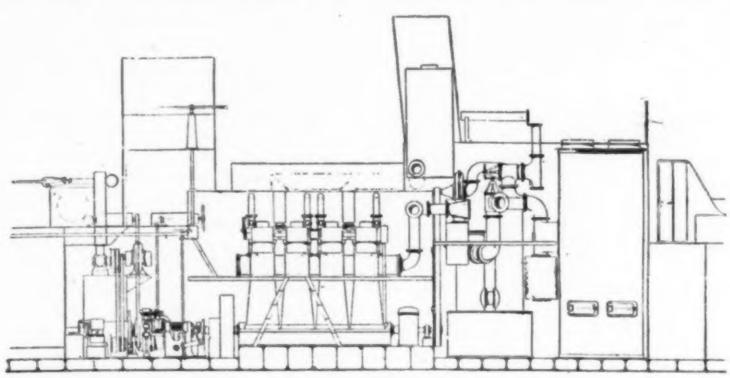
The "Deutz," by September 20th, 1909, or about three months after its first start, had already made twelve round trips, or 1,200 hours of towing. This speaks well for the reliability of its operation. The tug can average 3¼ miles per hour against the swift river current with two loaded twoboats with a total paying cargo of 3,200 tons. The tug with its tow makes a round trip in a little over 100 hours. Including coal used by auxiliaries and coal used during lay-overs, it averages 550 pounds of lignite briquettes per hour. This average is for 719 hours run, and includes all coal burned in the boat during this time. At a cost of $2.16 per long ton for the briquettes, the fuel cost for the return trip is $\frac{100 \times 550 \times 2.16}{2240} = \$55$. A barrel of lubricating oil containing 50 gallons is used each round trip.

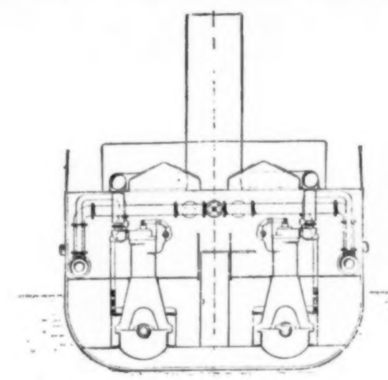
The crew for 16 to 18-hour days consists of captain, helmsman, machinist, helper, one or two laborers, and a sailor, or six to seven people in all.

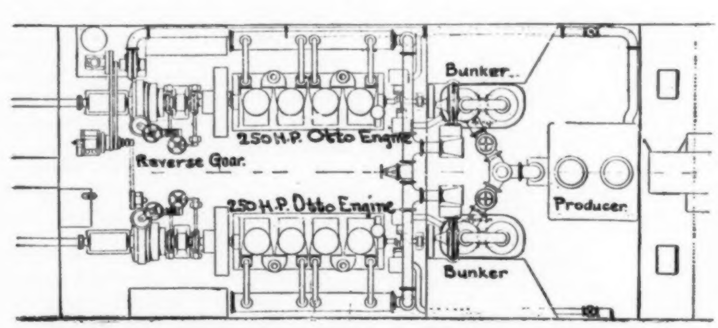
The attention to the producer consists principally in coaling, which is done by raising fuel by the bucket, using a winch, which is arranged to make it easy to drop the coal directly into the producer. There are two such lifts, one each for the port and starboard bunker. The fire is coaled every half hour, using one bucket from each side. Every two hours the grate is shaken a few times, and every eight hours the fire is clinkered. This work is done without dust or dirt.

It is true that a steam plant of the same rated horse-power can carry an overload occasionally, or even steadily, but this is at the expense of fuel economy. A steam plant cannot hope to use less than two and one-half to three times as much fuel for the same work under the most favorable conditions. When driving beyond its rating it smokes badly and the fuel economy is much worse. The gas plant has the advantage of being absolutely smokeless, and to permit forced driving, which has grown to be a custom, the rated power must be fixed with this consideration in view.

The gas-power tug surpassed the expectation of the builders in every respect; and while no doubt considerable work is still required to perfect the design of the power plant to the various kinds of marine service, the foundation of success has been assuredly laid. We may look forward to seeing on all our rivers within a few years clean and smokeless gas-power boats and tugs operating with an economy and efficiency till now unheard of.







POWER PLANT OF THE TUG "DEUTZ" EQUIPPED WITH 500-HORSE-POWER OTTO ENGINES AND PRODUCER.

THE N-RAYS.

A little book under the title "History of the Belief in the N-Rays," has recently appeared from the pen of H. Pieron. It shows how the N-rays were engendered in a great mind, ill-served by an excessively nervous temperament. An idea suggested by reflection or previous discoveries was able, in a field where the subconscious has an immense influence, namely, that of the observation of feeble phosphorescent phenomena in the dark, to excite the perception of variations in brightness systematized by *a priori* conceptions. The "rays" have shown us how coincidences and chances that may be traced in detail developed in the same mind a belief in the existence of all sorts of expected properties, and how contagion spread to other minds in which, according to their own prepossessions, new orientations developed new systems under the influence of *a priori* ideas; how, when suggestion did not work, the notion of authority caused others to admit what they could not see; they have shown us also the limits and modalities of the action of suggestion, the limits of the principle of authority which was hardly effective beyond the national frontiers, as well as the factors which opposed these first influences, among which must be recognized national rivalry and personal jealousy; they have revealed the mental character of many French physicists, and shown the necessity among specialists of a psychological and logical education which would doubtless have averted, in favorable surroundings, so long a propagation of an error so gigantic.—Science.

DEATH BY LIGHTNING.

ANCIENT AND MODERN VIEWS.

BY JOHN KNOTT, A.M., M.D., CH.B., AND D.P.H. (UNIV. DUB.) M.R.C.P.I., M.R.I.A., ETC.

The occasional announcement of a case of death by lightning is one of the most impressive items of evidence of the persistence of one of the tragic methods by which an inscrutable Providence still chooses to prove, through the intervention of a physical property of the atmosphere in which we live and move and have our being, that we have not yet arrived within measurable distance of a complete conquest of one of the well known powers of nature, even though when acting, as it habitually does, through one of the most familiar of all media.

With the rapid scientific progress of the past century, and the universal diffusion of the results of its conquests in the present conditions of universal education, every member of the community (at least of that overbalancing section of the same which is included in the rising generation) has assimilated fairly definite ideas of the more familiar, at least, of electric phenomena; and, "in a general way," of the causative mechanism of the same. A wide and barren desert of scientific exploration has indeed been traversed and mapped out—even to the minuteness of the millimetrical fraction of the fourth decimal place—since Plutarch edified and instructed the early generations of the Christian era by his collection of the formulated opinions of his greatest philosophical predecessors on this subject—as well as on so many others. Among other rare items of information regarding "thunders, lightnings, flashes, presters or fiery blasts, and tempestuous whirlwinds," we find in his entertaining thesaurus of "*Philosophers' Opinions*" (as rendered in the quaint old English of the famous "Translator-General," Philemon Holland, *Doctor of Physicke*) that: "Aristotle supposeth that all these Meteors come likewise of a dry exhalation, which being gotten enclosed within a moist cloud, seeketh means, and striveth forcibly to get forth; now by attrition and breaking together, it causeth the clap of thunder; by inflammation of the dry substance, a flashing beam; but Presters, Typhons, that is to say, burning blasts and whirlwinds, according as the store of matter is, more or lesse, which the one and the other draweth to it; but if the same be hotter, you shall see Prester, if thicker, look for Typhon." The modern scientist will, of course, ponder —with gratification—when he halts for a moment in his own seven league pace to contrast such scientific conceptions with those of the electrician of the twentieth century, who explains to us that "lightning is the visible discharge of electricity between one group of clouds and another, or between the clouds and the ground"; while the cause of the more alarming thunder is admitted to be the sudden expansion of the heated air; by means of which energetic movements are set going in the atmosphere, through which they are then transmitted from the center of generation of each in all directions. It is worth noting, as we pass, that the lugubrious sound of thunder, proverbially loud and intimidating, as it has always been regarded in the estimation of "the general," has hardly ever (if not absolutely never) been heard at a greater distance than fifteen miles, while the cannonading at the battle of Waterloo is said, upon evidence which has been accepted as thoroughly reliable, to have been audible at a distance of 115 miles!

Then, following upon the transient contemplation of "the thunder that frights," a passing glance at the nature and movements and (often too legible) effects of "the lightning that smites" will surely repay the reader's expenditure of time and thought. For it has a fairly full and decidedly interesting history—decorated, too, with a lavish embroidery of the most characteristic textures woven by superstition and folklore invention; and while its physical features and properties are of undeniable interest, its pathological associations may perhaps appeal more effectively to a still larger audience. With regard to the power of the lightning stroke, it is, of course, only those who have experimented somewhat freely with electrical apparatus, and have first-hand knowledge of the effects of sparks of eight or ten inches in length, who can form even a remote conception of the terrific power which dwells in the lightning flash during its progress of eight or ten miles. Death by contact with such a flash is, very necessarily, instantaneous; and visible marks of injury would necessarily be present on the surface of the victim's body and to some variable extent on the clothes; and much more definitely, on any article of metal carried on or in the same—or otherwise borne by the person. These, in the case of a very powerful flash such as we have supposed, must necessarily pass into a state of fusion. The ways in which lightning deals with the garments of its victims are very various; and, it should be candidly admitted, have in some well authenticated instances, remained quite inexplicable. I shall refer to this peculiarity again before concluding.

Another association of the history of this weirdly potent—and so often *ill directed*—weapon of Nature, had ever been regarded, down through all the prescientific centuries, as one of the most mysterious manifestations of the power of that inscrutable goddess. It had often been observed, with an awe as overwhelming as the surprise was inexplicable, that death sometimes occurred in the course of a lightning storm, and the most careful scrutiny failed to discover any marks of injury whatever, either to the body or the clothes of the victim. The materialistic nineteenth century did not fail to find an explanation in what has since been recognized as the *return shock*. Every substance capable of conducting the mysterious electric "fluid," on being placed in the vicinity of an electrified ("charged") body—and not connected to the same by a conducting medium—becomes charged with electricity of the *opposite* kind, and to approximately the same "potential" or "electromotive force." In accordance with the physical necessity which determines this process, a man may stand within a moderate distance of a thundercloud which holds an enormous charge of, let us say, *positive* electricity. In such position, his body necessarily becomes charged with *negative* electricity—by the influence of what is known as *induction*. While the state of equilibrium is maintained, without any abrupt disturbance, he feels no ill effect or inconvenience whatever. But when that cloud discharges its electricity in an opposite direction, the inductive influence instantaneously ceases; the induced negative charge is (in the same instant) neutralized by drawing an equal quantity of positive from the "universal reservoir" of the earth. The shock corresponds in intensity to that producible by the discharge from the cloud itself, and passes through the nervous system with such effect that the individual drops dead—instantaneously and without a single trace of injury on or around his person.

In cases of direct contact with the passing lightning flash, burns, more or less extensive and penetrating, have been noticeable; but, as a rule, there is nothing very remarkable about them. One of the most characteristic, indeed, of the *post mortem* conditions in cases of death by lightning is that when the shock has been direct and very powerful, the blood fails to coagulate after the normal fashion. [It will here interest some of our readers to recall the fact that the imperfect coagulability of the blood even after electrocution (the legalized mode of death by pigmy lightning shock) furnished a vast fund of sensational copy to New York journalists (and readers) who were ignorant of this fact (of modified physiology) at the time of the first employment of this method of carrying out the death sentence.]

While the causes of the phenomena of thunder and lightning remained unknown—being only guessed at in the most wildly erratic ways—and while their deadly effects were at the same time so unmistakably obvious, it is no matter for surprise (we would suggest to the twentieth century scientific reader who is endowed with charitable liberality of sentiment and elevation of viewpoint) that a widespread belief should exist in the minds of "the general" that such uncanny phenomena and effects were only to be accounted for by the presence in the surrounding atmosphere of potent and unfriendly agents over which (or whom) the powers and influence of man could have no direct control. Thus it was that when Benjamin Franklin rubricated the date of A. D. 1752 by bringing down the electric spark along his damped kitestring on the bank of the Schuylkill, he wrought—and with an electric velocity of peculiar appropriateness—one of the most far-reaching and permanent of all the revolutions known to the annals of human thought—as well as to the annals of human action. It was only after that most inspiring of the recorded epoch-making experiments that a vision of the possibilities of the uses to which electricity might possibly be applied began to dawn upon the collective intelligence of educated humanity. The consequent development of Franklin's protective *lightning* rod makes one of the most fascinating chapters in the romance of scientific history. It has removed a special source of terror from the stately mansions of modern civilization—especially significant in the case of urban public buildings as well as residential palaces—from the frequent proximity of the humble apartments of the poor, and the overcrowding therewith associated.

It might well be expected, indeed, by any perceptive student—or even much more superficial observer—of human nature, that the vagaries of superstition and the conjurings of imagination which were inevitably called into play by the fatal effects and peculiarly weird general properties of the lightning flash did not fail to take on the most grotesque forms—in every community, past and present, of whose primitive opinions we possess any reliable record. In that vast thesaurus of erroneous opinion, the "Historia Naturalis" of the Elder Pliny, we read (in the quaint diction of Holland's picturesque style and free rendering of his author) that: "Vessels are drawn drie, and their sides, hoops, and heads, never toucht there with a hurt, nor any other shew and token thereof is left behinde; gold, copper, and silver money is left in the bags, and yet the very bags no whit schorched; no, nor the wax of the seale hurt and defaced, or put out of order. Among the Cataline prodigies it is found upon Record, that M. Herennius (a Counsellor and Statesman of the incorporate town Pompeianum) was in a faire and cleare day-smitten with lightning." We are informed by the same encyclopædic authority that the "antient Tuscanes" held that there were *nine* gods that sent forth lightning, while this weird weapon of those superhuman agents presented no fewer than *eleven* varieties. The Romans attributed the lightnings of the daytime to Jupiter and those of the night to Pluto.

Some of the expert professed to have reasons for knowing that the "burning lightning" came from the planet Mars, while the other was emitted from Saturn. Numa, the original lawgiver of the Roman commonwealth, was credited (by posterity, at least) with the possession of power to control the lightning. We are also told that when Tullus Hostilius tried to imitate his performances in this department, he was himself killed by a lightning stroke. (And will not the philosophic reader here recall and compare the fate of the martyr enthusiast in electricity, Richmann, of St. Petersburg?) We admit (as I shall take the opportunity of pointing out to the reader) at this stage that a great deal of the sensational decoration which invests the newspaper reports of the conditions found after death by lightning may be at once attributed to the artistic imagination of purveyors of "copy." For instance, the tearing away of garments and flinging the bodies to long distances. Each of these conditions is quite credible—within a limited range. The sudden heating of the air between the clothes and integument would account for the former; the violent muscular convulsion for the latter.

Thunder and lightning were, of course, very significantly auspicious, as every schoolboy has learned from his Vergil. We are told by Pliny (again *via* Holland) that, as regards the teaching of the sooth-saying augur whose function it was to interpret the mysteries of the upper and nether worlds to the exiled Roman pilgrim of our planet's surface: "Those lightnings that are on the left hand, he supposed to be luckie and prosperous, for that the East is the left side of the world, but the coming thereof is not so much regarded as the return, whither the fire leaped back after the stroke again."

Then the deadly meteor was known to display eclectic tendencies, even in the moments of its most destructive progress. Of all specimens of the vegetable kingdom: "Lightning blasteth not the Laurell tree." Then, of the volant denizens of the air, the eagle was never struck; and, on that account, the proud and privileged bird was respected as the armorbearer of Jupiter. And among the citizens of Neptune's empire, to the seal (or seacalf) alone was assigned the privilege of enjoying the corresponding immunity.

Philosophical scientists and physicians are much indebted to the famous historian of the "Twelve Cæsars," C. Suetonius Tranquillus, for having recorded for their edification the feelings which were elicited in the breasts of some of the early Roman emperors by those meteoric phenomena. Thus, we learn of Augustus that: "Thunder and lightning hee was much afraide of; insomuch as alwaies and in every place, hee carried about him for a preservative remedy a Seales Skinne; yea, and whensoever he suspected there would be any extraordinarie storm or tempest, he would retire himself into a close secret roome under-ground, and vaulted above head, which hee did, because once in time past, hee had been frightened with a flash of lightning." I feel it to be an item of imperial duty on my own part to illustrate the wisdom of this last mentioned very practical method of safeguarding his person, by mentioning that Pliny assures his readers that light-

ning never penetrated the earth's crust beyond a depth of *five* feet!

The bodies of persons who had been struck by lightning were believed to be incorruptible; and it was the popular opinion, too, that even the bodies of those persons who had been scorched only, not fatally injured, by lightning, continued to remain after death distinguishable by the peculiarity that they remained persistently proof against the ravages of decomposition. On this head Plutarch informs us (Englished by the same "Translator-General" of the gossiping pagan historians) that "the dead bodies of those who have been killed by lightning, continue above ground and putrifie not; for many there be who will, neither burn nor enterre such ecorses, but cast a trench or bank about, and so let them lie as within a rampart; so as such dead bodies are to be seen always above ground uncorrupt; convincing Clymene in Euripides of untruth, who, speaking of Phaethon, said thus:

Beloved mine, but see where dead he lies,
In vale below, and therewith putrifies.—"

Thus the American scientist and physician of the twentieth century can produce the highest and noblest reasons, based upon the deepest and firmest foundations of national patriotism and cosmopolitan philanthropy, for pointing with dignified gratification and pride to the imperishable record of how the mystery which so utterly baffled the almost divinely inspired philosophers of the most brilliant of the older civilizations, yielded up its secret at last to the penetrating scrutiny of the Philadelphian journeyman printer. The most startling atmospheric phenomena of all the ages and countries thus was destined to have its heart at last plucked out by the self-taught Western amateur. And thus it is that not only are we enabled to form a mental picture of what takes place as the lightning flash zigzags its way on the stepping stones presented by our atmospheric dust, but we are protected within our "sky scrapers" by the competent guardianship of Franklin's *lightning rod;* while in the event of being caught in the thunderstorm of a country holiday, we are warned from the shelter of the neighboring tree or haystack by our knowledge of the nature of *return shock*.—New York Medical Journal.

AN EARLY WRITING ON THE HESSIAN FLY.

A COLONIAL LETTER ON A FORMIDABLE PEST.

BY PAUL GRISWOLD HOWES.

It has been the good fortune of the writer to come into possession of an old letter from one Col. Morgan to the president of the Philadelphia Society for the Promotion of Agriculture, published by that society in the American Museum for September, 1787, relative to the destructive Hessian fly, first introduced into this country in the year 1779. It is the general belief that the fly came to the United States in the bedding of the Hessian troops during the war of the Revolution.

It is now the most destructive fly to the wheat crop of America, causing an annual loss of many millions of dollars. This enormous tax is being paid annually by the farmers of the country. The eggs are laid by the tiny insect in the furrows of the young wheat leaves. These hatch in a very few days and the young larvæ wriggle down to where the leaves join the main stem. Here they drain the plant of its sap, causing it to grow weaker and weaker until the full-grown larvæ transform into the pupal state, which closely resembles a flax seed. If their ravages stopped here it might be all very well, but not so; for the pupæ soon split and a second brood, much larger than the first, are ready to lay their eggs. There are four, possibly as many as five generations a year. If it were not for their natural parasites, there would be very few wheat fields in the country.

The following is a copy of the old letter which contains many interesting facts and clearly demonstrates the interest taken in this subject nearly one hundred and twenty-five years ago:

July 25, 1787.

Dear Sir: My information to the society, respecting the Hessian fly, would be incomplete were I not to add my further remarks on this destructive insect, which, I am sorry to inform you, has crossed the Delaware, and will make considerable advances southward and westward the present season.

I think it proper to confirm every particular mentioned in my letter of the twentieth of May, except such as I shall here differ in, from having had better opportunities, and from more attentive observations, than I have had it in my power to make until now.

Having hatched and bred a number of these insects from the chrysalis into the fly state last year, I became well acquainted with them and watched all their motions.

As I have already described the nit* and chrysalis, I need now only say, that the fly which proceeds from the latter is at first of white body with long black legs, and whiskers, so small and motionless as not to be easily perceived by the naked eye; but with a microscope they are very decernible. They soon, however, become black and very nimble, as well on the wing as on the feet. They are about the size of a small ant. The vial, which will be handed to you with this, contains a number of the flies, which were living and of full growth when I put them into it. I will also add a few of the nits, in which state they destroy the wheat.

I have, during the height of the brood in June, where fifty or a hundred of these have been deposited in one stalk of wheat or barley, discovered them to twist and move on being disturbed. This is while they are white. But they do not then travel from one stalk to another nor to different parts of the same stalk.

The usual time of their spring hatching is in May, but this last season having been cold and backward, the fly did not make its appearance in my neighborhood until June, by which time the wheat was far advanced, and from the favorableness of the season in other respects, we have had good crops, notwithstanding that there was not a stool of wheat in any of our fields, but had the first shoot killed last fall. The grain is large and heavy in the bushel, contrary to our expectations, and the information we had received.

In my neighborhood this insect has made little impression upon the rye, which will induce our farmers to depend principally upon that grain instead of wheat. Oats and buckwheat escape their ravages altogether.

My barley promised well until June, at which time it was full of juices and suited the taste of the insect, to that degree as to occasion its almost total destruction.

Those who are in doubt of the fly's presence in their neighborhood, or cannot find their eggs or nits in the wheat, may satisfy themselves by opening their windows at night and burning a candle in the room. The fly will enter in proportion to their numbers abroad.

The first night after the commencement of the wheat harvest this season they filled my dining room in such numbers as to be exceedingly troublesome in the eating and drinking vessels. Without exaggeration, I may say, that a glass tumbler, from which beer had been just taken at dinner, had five hundred flies in it within a few minutes. The windows are filled with them when they desire to make their escape. They are very distinguishable from every other fly by their horns and whiskers. These circumstances will not appear trivial to you, nor to any other lover of agriculture; nor to the naturalist.

In my letter of the twentieth of May, I mentioned a species of wheat, grown on Long Island, said to resist the ravages of the fly, whilst every other kind of grain perishes under it. I took the liberty to suggest to the society, the advantages which might arise to the public from their sending an observant person to ascertain the fact. Some of my neighbors to whom I made the like proposition, took up the matter and one of them, Mr. Thomas Clark, who is not only a good farmer, but of perfect veracity, undertook to visit that part of Long Island where the fly made its first appearance in 1778, and where it has continued ever since, although it is now greatly decreased—so much, indeed that the inhabitants in general think that they had none this season; though Mr. Clark says they are nearly as numerous as we have them here at this time. He has made his report to us in writing, as follows:

Stony Brook, July 20, 1787.

Agreeably to the request of my neighbors, and my promice, I left home on the twenty ninth day of last month, and arrived at Long Island the day after.

On the best examination and inquiry that I could make, during my stay there, which was until the forth of this month, I satisfied myself in the following particulars, viz.

That the Hessian fly made its first appearance there about the year 1779, so as to injure, and in some cases to destroy their crops of wheat. That their crops have failed more or less every year until the present. That their goodness this year is attributed to the introduction of a new species of wheat, which, from several years of experience, is found to withstand the attacks of the fly, so as to yeald good crops, whilst every other kind of wheat has suffered considerably, or been totally destroyed.

That the wheat which has been found to so resist the fly, is a yellow bearded one, not the red, nor the white bearded wheat.

That it was first accidentally introduced there from a schooner in the year 1781, taken in the Delaware River, and carried into New York, from whence it was sent to I. Underhill's mill on Long Island to be ground.

That I. Underhill reserved some of it for seed and sowed it with success, whilst his neighbors lost their crops. This encouraged him to persevere, and he spared some seed to others, from the idea that as it was a different kind of wheat, its success might be owing to that. Their expectations were answered, whilst all other kinds of wheat failed wholly, or in part; insomuch that general conviction has now taken place, and little or no other wheat will be sown on that part of the island, as long as there are any appearances of the fly in the country.

These circumstances induced me to engage my wheat whilst I was on the island: and I recomend to my neighbors who intend to sow next fall to send there for their seed. It may, perhaps, be well for a number to join and send a person for the wheat, that no mischief may arise from getting foul grain. The price they hold their seed wheat at is. 10s. and 11s. New York money, in specie, per bushel.

I find that the fly does not injure rye on Long Island, but very little, and oats not at all, nor buckwheat. I could get no satisfactory information respecting barley. (Signed) T. Clark.

Col. George Morgan.

It would be extremely interesting to trace, if possible, the records of this "yellow-bearded wheat" on Long Island and find out what became of it in the years which followed the writing of these curious, but nevertheless very interesting old letters. Wonderful to me is the great enthusiasm shown in those old days about the wheat crop, but perhaps it meant bread and butter, who knows?

* The nit is the larval state. A word seldom used in modern science.

THE VELOCITY OF BULLETS.

The method devised by Crantz of measuring the velocity of a bullet by spark photography is set forth in a recent number of the Engineer. The apparatus consists essentially of a horizontally pivoted revolving drum, covered with a photographic film, past which the bullet is fired. The bullet is illuminated as it passes the drum by a succession of electric sparks discharged at a given rate of 5,000 per second. The frequency of the spark and rate of revolution of the drum being known, the velocity of the bullet can be determined by measuring the distance apart of the images. This measurement is facilitated by interposing a glass rule divided into millimeters between the spark and the drum; this, as well as the bullet, is photographed at each spark. To measure the reduction in velocity due to the resistance of the air or to passage through a plate, two such drums are used, special arrangements being made for synchronizing the drums and identifying the corresponding images of the bullet on each drum. The reduced distance apart of the images on the second drum gives the loss of velocity due to air-resistance, and the "lag" of the image of the second drum behind that on the first drum gives the time of flight over the distance between them. To keep the images clear a pendulum contact-breaker is used, which cuts off the current except during the small fraction of a second while the bullet is passing the drum. The same pendulum makes the electric contact which discharges the rifle. It is estimated that bullet velocities can be determined by this method with an error not exceeding $\pm$ 0.3 m. sec. The principal use to which the apparatus is likely to be put is to determine the relative resistance of the air to bullets of different shapes. The ordinary Le Boulengé chronograph shows merely the time of flight between two given points, and the result is affected by any variation in the muzzle velocity, as well as by the possible check experienced by the bullet in passing through the first chronograph screen. The Crantz instrument gives the actual velocity at each of two given points, as well as the time of flight.

THE MECHANICS OF SAVING LIFE.—I

SAFETY PROVISIONS IN THE UNITED STATES STEEL CORPORATION.

BY DAVID S. BEYER, CHIEF SAFETY INSPECTOR, AMERICAN STEEL AND WIRE COMPANY

Fig. 1.—ELECTRIC CRANE DRAWING HOT INGOT FROM PIT FURNACE.

In many departments all daily tonnage is handled one or more times by cranes. The wheels of a crane are visible on the runway overhead with "sweep brushes" in front of them.

At the outset it should be explained that this article is not intended to be either "popular" or "technical," in the accepted sense of these terms. If it were framed on purely technical lines it would presuppose a thorough knowledge on the part of its readers of power generation—of machinery—of industrial organization—and would resolve itself largely into a statement of rules, specifications, methods, and appliances, that would be both uninteresting and incomprehensible to any one who did not have this knowledge. On the other hand, to explain to an outsider mechanical construction and operation of, for instance, the different types of electric cranes, with the accidents which may occur on them, and to make clear the value of the rules and safety devices which have been worked out to prevent such accidents, might readily fill the entire space allotted to this article. The attempt will be, rather, to touch in a general way on some of the principal features of safety work in its present stage of development in the United States Steel Corporation, and to give some impression of the problems encountered, and how they are being solved practically.

This work is a logical outgrowth of association with the accidents which must inevitably accompany the use of machinery. It is probably safe to say that the "casualty" or "accident" department has always preceded the "safety" department; that dealing with the men who have been injured has brought about a desire to prevent the recurrence of accidents. From the first scattering efforts in this direction have grown more systematic methods, until accident prevention has developed such a variety of detail and such breadth of possibilities that it is fast becoming a technical branch of itself. What was originally a species of self-defense has broadened out into more humanitarian lines, until at present it is being taken up on a scale that would not have been dreamed of in this country a few years ago. Safeguards once considered entirely satisfactory are being replaced by others of improved construction. New forms of protection are constantly being devised.

In some of the companies which were brought together in 1901 to form the United States Steel Corporation, organized safety departments have existed for the last fifteen years; in all of them more and more attention has been given to safeguarding employees, until at present each of the main constituent companies has a corps of trained specialists who devote their time to studying the causes of accidents and to devising means to prevent them. New impetus was given this work by the interest manifested in it, and the policy adopted toward it by the officials of the Steel Corporation. Every year all the men in charge of these matters for the several subsidiary companies have been called together at the general offices in New York for discussion of the problems connected with their work, the first general meeting being held in May, 1906. At these meetings the officers of the corporation have given assurances of support to the subsidiary companies in every practical undertaking for the prevention of accidents. This resulted in the formation in April, 1908, of a central committee of safety.

This committee is composed of five members representing subsidiary companies operating the largest plants and mills, with an officer of the United States Steel Corporation acting as chairman. It was empowered to appoint inspectors to examine the various plants and equipment, and submit reports of safety conditions, with suggestions for improvement. The committee was further requested to record and disseminate data on regulations, rules, devices, etc., tending toward safer working conditions in the plants.

Some idea of the breadth of the field before the new committee may be gained from the fact that it includes 143 manufacturing plants, in addition to mining and transportation properties, employing in all approximately 200,000 men.

The committee has selected as its inspectors men already engaged in safety work in the subsidiary companies; in other words, the matter has resolved itself largely into a system of inter-company inspection, which gives the plants inspected the benefit of new viewpoint and varied experience and at the same time enables the inspectors themselves to see what is being done elsewhere, and to carry back new ideas and devices to their own plants. The plan has worked well and has been of great assistance to the several companies, who hitherto had been coping with their own safety problems without definite knowledge of what other members of the great corporation family were doing.

Meetings of the committee are held about once a

2810

AMERICAN STEEL & WIRE CO.

________________ WORKS

SAFETY INSPECTION OF CRANES. DATE ____________

CRANE No.													
Drums, Chains, Cables and Hooks													
Wheels and Flanges													
Brakes and Bells													
Sweep Brushes and Bumpers													
Track Clamps													
Draw Bars and Push-Poles													
Motors, Generators, Electric Wiring etc.													
Foot-Walks and Railings													
Warning Signs													
Any Other Part Not Specified Above													
Does Operator Consider Crane Safe? Should Crane be Shut Down Immediately Until Repaired?													

Designate Parts Inspected and found O. K. by "X."
Designate Defective Parts by a letter, using A, B, C, etc., and give explanation of Defect in Blank Space Below

Fig. 3.—FORM USED FOR WEEKLY INSPECTION REPORT OF SPECIAL MACHINERY.

These forms (5 inches by 8 inches with wide margin at bottom for memoranda) are filled out by local safety inspectors in each plant.

Fig. 2.—HOT STEEL INGOT ENTERING THE ROLLS OF BLOOMING MILL.

Table gears on right are covered with swinging guards of steel plate.

* The Survey.

month, when arrangements for inspection are made, and reports considered. Drawings, photographs, rules, specifications, etc., are submitted for consideration, and such as seem desirable are sent out to all the companies. During the two years since the institution of this central committee of safety, its inspectors have reported to it, in round numbers, 6,000 recommendations for increasing the safety of employees in the plants, mills, mines, and on the railroads and steamship lines of the organization. Of these recommendations ninety-three per cent have been adopted by the committee and carried out by the subsidiary companies. New appliances, guards for the protection of machinery, and other means for safeguarding the workmen, to the number of one hundred or more each year, have been submitted for the consideration of the committee, and through the committee have been brought to the attention of and adopted by the subsidiary companies.

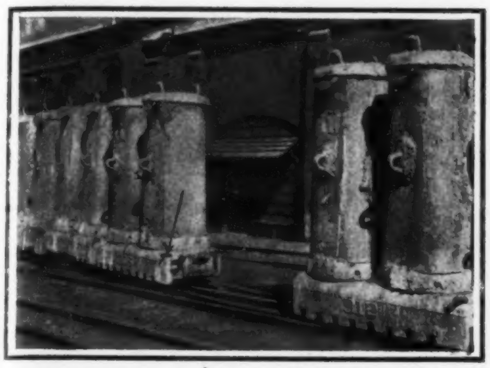


FIG. 4.—INGOT MOLD CARS EQUIPPED WITH AUTOMATIC COUPLERS.

When cars are pushed together the coupling pin drops into the link automatically; to release it the lever shown on corner of car is raised by hand.

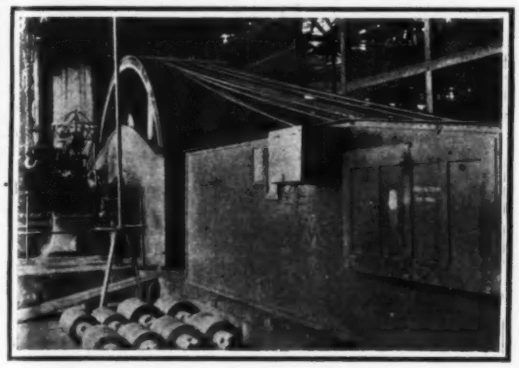


FIG. 5.—VIEW OF ROPE DRIVE FOR ROD MILL, SHOWING STEEL PLATE INCLOSURE.

There has been no attempt to establish a uniform safety organization in each of these companies, since the conditions vary so greatly that this would be impracticable. The Carnegie Steel Company has twenty-seven different plants; the Illinois Steel Company, six; the National Tube Company, thirteen; the American Sheet and Tin Plate Company, thirty-four; the American Bridge Company, sixteen; the Tennessee Coal, Iron and Railroad Company, seven, and the American Steel and Wire Company, thirty-two. In some cases the plants of a company are grouped within a radius of a few miles, in others they are located in as many as ten or twelve States. While each company thus has its own safety organization, which has been evolved during a period of years, there are many features common to all. The following pages treat particularly of the organization and methods used in the American Steel and Wire Company, but it should be borne in mind that many of the devices and ideas found in its plants were secured from some of the other companies mentioned, through the central committee of safety and the system of inter-company inspection.

The American Steel and Wire Company has plants in Worcester, Mass.; New Haven, Conn.; Trenton, N. J.; Pittsburg, Donora, Allentown and Sharon, Pa.; Cleveland and Salem, Ohio; Anderson, Ind.; DeKalb, Joliet and Waukegan, Ill.; San Francisco, Cal., and Hamilton, Canada. Its equipment includes docks and ore handling machinery, blast furnaces, open hearth furnaces, Bessemer converters, blooming mills, plate mills and rod mills; finishing departments for making nails, fence, market wire, etc., as well as specialty departments for springs, electric cables, rail bonds, wire rope and flat wire. It unloads a boat of ore from the Michigan mines at its docks in Cleveland, reduces this to pig iron in its blast furnaces, converts the iron into steel ingots in open hearth or Bessemer departments, rolls these ingots out into billets in a blooming mill, reduces the billets to a quarter-inch rod in the rod mills, and draws this rod down into the wire from which your watch spring is made, or your telephone connected up.

To do this there is a great variety of machinery, and the problem of bringing this equipment up to approved standards of safety, and maintaining it in this condition, is complicated by the widely separated locations of the plants. The logical outcome has been to place the responsibility largely in the plants themselves, with such oversight and assistance as are necessary to obtain satisfactory results. Accordingly, special inspectors have been appointed and local inspection committees organized; there are two of these committees in each mill, one of which is called the "foremen's committee," and the other the "workmen's committee."

LOCAL COMMITTEES.

The foremen's committee usually includes the assistant superintendent of the plant, the master mechanic, chief electrician, and a department foreman or two. Some of these members are retained permanently on the committee, so that they may gradually become educated to the full scope of the work. By changing one or two members at intervals, numbers of foremen receive the benefit of this experience. It is the duty of the foremen's committee to make an inspection of the plant either semi-monthly or monthly, and turn in a written report; furthermore, it goes over the recommendations of the workmen's committee, which reports weekly.

The workmen's committee is entirely distinct, and is taken from the rank and file of our mill employees; for example, there may be a machinist, an electrician and a wire drawer—or a roller, a millwright, and a carpenter, etc. These men are selected by the superintendent in consultation with the foreman from whose department they are taken, workmen of good intelligence being chosen, who will take an interest and be able to make their work count. There are from two to four men in this workmen's committee, depending on the size of the plant. They serve on the committee for a month, making one inspection a week, each inspection consuming about a day. At the end of the month an entirely new committee is appointed, and both the incoming and outgoing committees meet with the superintendent who explains to them something of the object of their committee work. Those who have completed their term of service are told that they are to consider themselves permanently on the safety committee, and to feel free at any time to mention anything which they think conducive to their own safety or that of their fellow employees. The men, pleased, of course, at the opportunity to meet the head of the plant, take considerable pride and interest in the safety work, and are coming to realize more fully its importance. Several superintendents state that the early members of these committees are still making suggestions, and they undoubtedly bring up many things that otherwise they would not mention at all.

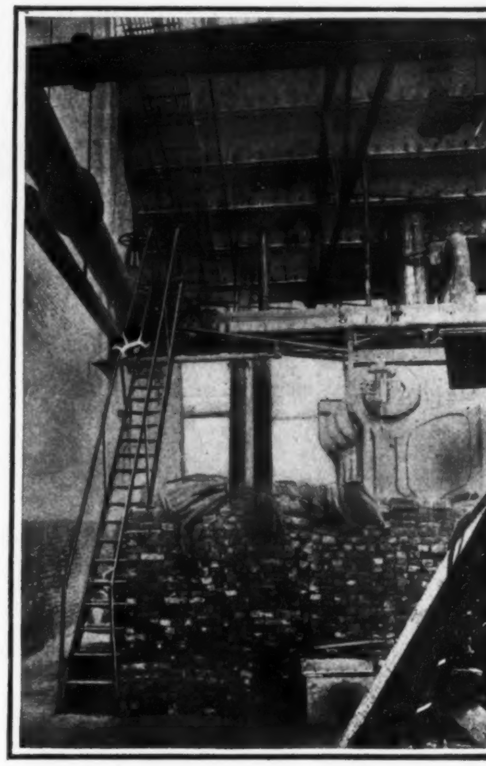


FIG. 6.—ANOTHER VIEW OF FIG. 7.

Stairway showing overhead cross walk of steel grating; this walk extends along the top of boilers and gives access to each of the main valves.

The details of the committee organization are left largely to the local managers, who adapt the scheme to local conditions and bring some of their own ideas into play. One superintendent makes out the lists of workmen's committees for several months, and posts them in the mill so that the men will see them and know some time ahead that they are to serve on the committee. He says that they like to see their names used in this way, and "load up" in advance for the time when they are to begin this service. At another plant it is customary to have one member of the foremen's committee go about with the workmen's committee to explain and discuss any problems which may come up. While there are these local variations in the different plants, the plan and scope of the work are the same in

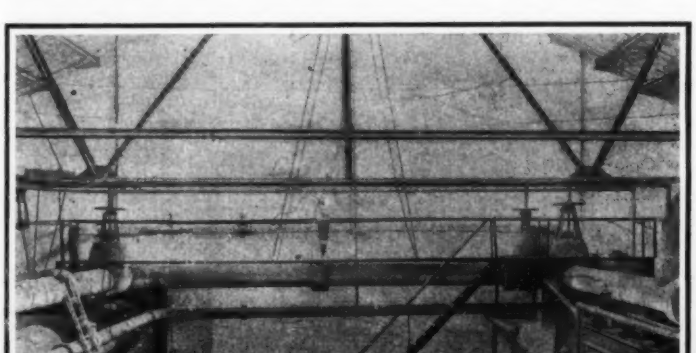


FIG. 7.—STAIRWAY FOR REACHING OVERHEAD VALVES AND PIPING IN BOILER HOUSE.

The old method of doing this is indicated by ladders on the left.

FIGS. 8 AND 9.—GAGE GLASS FOR INDICATING HEIGHT OF WATER IN BOILER.

When steam is turned into a new gage glass, the guard is revolved to the front to prevent injury in case glass should burst. Semi-circular steel guard shown in its normal position.

all. Each committee makes a written report of its inspection, the recommendations of which are numbered, and the numbers of any incomplete items are all shown on a monthly statement until they have been carried out as mentioned later.

Our experience with these committees has been uniformly satisfactory. Benefits accrue both from the actual recommendations, and from the enlivened interest which the men are taking in safety appliances. A master mechanic of one of the large plants said a few days ago that he can notice a decided change in the attitude of the men toward safety matters since these committees were established; that where he used to have difficulty in keeping any safeguards in place, the men are now looking out for them and helping keep them up. Some of the things they bring to light are such as might escape an outside inspector in a dozen trips through the mill. For instance, one of the workmen's committee recently called attention to a platform which was so placed that when it rained the water deflected back into the "mixer building," where melted iron is constantly being handled. This water lying in pools on the floor would cause a serious explosion if hot metal were spilled into it. Other items refer to gear covers which have been taken off and not replaced; to steam which forms in cold weather and obscures an open reservoir; to elevator gates which have been tied up so as to make them ineffective; to places which are poorly lighted at night, etc.

MILL SAFETY INSPECTORS.

There are certain classes of equipment that require thorough inspection at frequent intervals by men of special training, who can go over them in greater detail than is possible for the mill committees. In this class are electric traveling and locomotive cranes, engine stops, elevators, shop equipment, cars, locomotives, etc., and for them special inspectors have been appointed, who make a weekly report on a printed form. At present we have nine such forms in use, similar in arrangement to the crane report shown in Fig. 3. It will be noted that the important parts are all specified, and each part is checked off on the form as the inspector goes over the cranes; one of the headings requires the man who is operating the machine to state his opinion as to its safety, and there is a provision for stopping it at once if any serious defects are found. There are at present twenty-eight men engaged in such official inspection in the American Steel and Wire Company's plants, aside from the local committees. In the larger works this takes all of one man's time, while in smaller ones two or three days a week may be sufficient, the inspector working as a machinist, electrician, etc., the rest of the time.

The reports of foremen's committees, workmen's committees, and safety inspectors are compiled once a month, and copies sent to the general offices of the company. These statements include all new items, and at the end of each report show the "Recommendations Completed During Current Month," "Previous Recommendations Incomplete," "Recommendations Objected To" (if any), with reasons for objection. This gives a monthly survey, from which a good idea may be obtained of the general condition and progress at each plant, and additional pressure may be brought to bear where the progress is not satisfactory.

Aside from the practical value of the recommendations secured, there is a moral effect in this varied inspection which must not be overlooked. The foremen, millwrights, and repairmen—all who are in any way responsible for the condition of the machinery—are stimulated to greater care and attention in keeping everything in good shape. The knowledge that any defects will be mentioned on an inspection report (sometimes on two or three) each week until the defect has been remedied or the delay investigated, undoubtedly does much to prevent tardiness in carrying out this work. During the month of January, 1910, there were approximately 1,500 specific recommendations made by these different inspectors and inspection committees in the American Steel and Wire Company's plants. Of these over 500 had been entirely completed before the end of the month, with material ordered and work under way on a great many more.

BOILER PLANTS.

In mills driven by steam engines the boiler plant is the primary source of power. It generates steam which is piped to the engines, and is a storehouse of energy so great that when any mischance releases this energy in the form of an explosion, buildings are demolished and lives endangered. The possibility of such catastrophies has been so emphasized by repeated boiler explosions that most States and municipalities have laws requiring a systematic inspection of boilers by authorized inspectors. In the United States Steel Corporation this is done by an outside inspection company which makes a specialty of boiler insurance, each boiler being thoroughly inspected at least once in six months.

In addition to this inspection, which is directed mainly to the detection of corrosion or defects which might lead to an explosion, many minor arrangements can be made to contribute to the safety of men whose duties require their presence in and about boiler plants. The failure of a part in a boiler or steam pipe, insignificant in itself, can instantly involve men and machinery in a cloud of blinding vapor, so that ladders and passages that would be safe under normal conditions may bring misfortune upon the workmen groping about with ineffective vision. Under such conditions prompt and unimpeded access is needed to overhead valves and connection, stairways being preferable to vertical or inclined ladders, and all stairways, walks, tops of boilers, etc., across which it is necessary for workmen to pass, should be thoroughly protected by hand rails, and well lighted. Figs. 6 and 7 show stairways in one of our boiler plants.

The arrangement of piping may be such as to form what is known as a "water pocket," that is, a place where water gathers from the condensation of the steam. The opening of a valve will shoot this water forward with sledge hammer effect, bringing disaster to the piping system or the machinery to which steam is furnished, and endangering the lives of all who may be near. Water pockets should be guarded against in designing a system of steam piping, but where oversight or necessity has brought about such a form of construction, the danger has been obviated by placing a "drip" in the water pocket, that is, a small drain with a valve through which the objectionable water may be allowed to flow from the pipe before a main valve is opened.

Many plants are provided with a tunnel underneath the boilers, through which, where coal fuel is used, the ashes are removed. Not infrequently these tunnels are so arranged that there is a "dead end," from which there is no means of egress. A break which would let steam or hot water flow into the tunnel and cut off escape by the one outlet provided would be liable to scald or suffocate any workman who happened to be in this section of the tunnel. Six cases of tunnels with "dead ends," which have come under our observation in the past two years, have been corrected by providing additional doors, ladders, or other outlets.

Every boiler is equipped with a gage glass, that is a vertical glass tube about three-quarters of an inch in diameter, by which the height of the water in the boiler can be known. These glasses frequently break as they are subjected to the same steam pressure as the boiler itself, which may be from 100 to 150 pounds per square inch, with a temperature of from 300 to 350 deg. F. When a boiler tender opens the valve after putting in a new glass it is liable to explode before his face like the cannon cracker which the boy celebrating the Fourth of July holds too long after lighting, and the results are much the same—more or less severe cuts and burns, and possible destruction of his sight. Danger from this source has been eliminated by using the gage glass guard shown in Figs. 8 and 9. This guard is made of sheet steel and can be turned in front of the glass when anyone is working about it. After the work is done it is swung around back of the glass so as not to interfere with the view of the water.

A number of our boiler plants have been equipped with non-return valves, which only come into play in case of an accident. There may be 10,000 horse-power of boilers connected into one piping system, so that if any part of a boiler or main steam pipe fails, this stored-up energy will be released with terrific force at the point where the break occurs, until valves can be closed or fires drawn and the boilers cooled down. The non-return valve closes automatically in case of accidents of this sort and thus brings the system under control without the risk which must be taken by men going in to close the valves by hand.

Three connections are necessary for each boiler—one through which water to be evaporated is admitted, a connection from the boiler to the main piping through which the steam is carried away, and a connection to a system of "blow-off" piping, so that the sediment which settles from the water can be blown out at intervals. Entrance to a boiler is obtained by means of a "manhole," which is just about large enough to enable an averaged sized man to wriggle through comfortably, a process which cannot be accomplished very quickly. Thus the workman who enters a boiler, while other boilers of the same plant are in use, is necessarily at the mercy of the men outside, as the accidental opening of a valve might result in his serious scalding. There are long rows of these valves exactly alike and mistakes are liable to occur. To guard against this the valves have been numbered and red warning signs marked "Danger—do not move" are hung on them when anyone is in a boiler. Wherever practicable, it is made the duty of the man doing the work to place these warning signs.

(To be continued.)

AN ELECTRIC VACUUM FURNACE.

An electric vacuum furnace is described in the Berichte by O. Ruff. The essential feature of this furnace is a tube of retort-carbon, turned down till the thickness of its walls is 1 to 1½ millimeters, and provided with two slits opposite one another about the middle of its length, for visual or pyrometrical observation of the contained crucible. If it is desired to increase the resistance of the tube further, this is done not by thinning it down, but by cutting a symmetrical series of narrow short slits all over it, and thus diminishing the conducting area. Over the ends of the tube there slide well-fitting stout jackets of retort-carbon, coppered on their outer ends, where they make contact with water-cooled iron blocks to which the binding-screws for the current are fixed. The whole is covered with a non-conducting jacket, and inclosed in a water-cooled brass case. This case is furnished with two view-holes glazed with quartz-glass, and provided with the necessary connections for exhaustion. Tubes are also provided which permit either of passing various gases through the furnace tube, or of introducing through stuffing-boxes the wires of a pyrometer into the crucible. According to the thickness of the tube, 200 amperes at 15 to 18 volts give a temperature in the crucible, as measured by a Wanner pyrometer, of 1,000 to 1,300 deg. C., and 650 to 700 amperes at 28 to 40 volts a temperature of 2,000 to 2,700 deg. C. Higher temperatures are not realizable on account of the rapid volatilization of the carbon. With a good vacuum, the reducing effect of the atmosphere in the furnace is, even at the highest temperatures, very slight. By substituting water-cooled carbon electrodes for the iron block bringing the current, the furnace can be used as an arc-furnace. Ruff states that he has used the furnace to prepare 96 to 97 per cent vanadium, by reduction of rods of a paste of vanadium trioxide, carbon and starch in the tube furnace, and fusion by the arc of the sintered metal so obtained.

The melting points of various materials were determined by watching for the sinking down of cones made from them and heated in the carbon crucible: the temperature of the crucible (which was probably less than 50 deg. different from that of the object within) was read as the melting point. The results obtained were: Platinum, 1,745 to 1,755 deg.; commercial molybdenum, 2,110 deg.; iridium, 2,210 to 2,225 deg.; kaolin, 1,910 to 1,915 deg.; pure tungsten, 2,575 deg. C. Titanium (containing about 5 per cent of carbon) only began to show indications of approaching fusion at 2,700 deg. C. Alumina, magnesia, and lime were found to be so readily volatile that their melting points could not be determined *in vacuo*. In nitrogen at atmospheric pressure alumina melted at 2,065 deg., lime about 2,035 deg., with formation of a felted mass of fine strongly refracting needle-like crystals; magnesia remained unmelted at 2,400 deg., but in all probability did not reach the recorded temperature as it volatilized, even at atmospheric pressure, so rapidly. Attempts were also made to determine the electrical resistance of these oxides just below their melting points, and to investigate the behavior of carbon at high temperatures toward silicon tetrafluoride. In the last case no reaction was observed.

With a total output of 26 vessels, aggregating 43,097 tons, the Clyde shipbuilding industry scores one of the best Julys on record. In the corresponding month of last year the launches aggregated only 20,172 tons, the record being 67,300 tons in 1907. There has recently been a lull in the placing of new work, but prospects are again improving, and full time working up to the end of the year is now assured.

THE JUDGING OF RUBBER GOODS.

On the above subject the Gummizeitung says: The determination of the quality of rubber goods is often effected from entirely erroneous view-points. Thus, for instance, the opinion prevails that the softest qualities are the best, which in the case of certain combinations, for tough hose, or valves, is by no means the case. It is just as wrong to draw conclusions as to the quality of the goods from their color or to base a judgment on energetic pulling and bending tests. This opens the door to mistaken conclusion. If we can bend a semi-circular formed hard rubber child's comb of very thin make, out flat, its quality will be recognized as excellent; a similar experiment cannot be conducted with an equally good comb, of heavier make, without breaking the object of the experiment, which would then erroneously be regarded as of inferior quality. There are many such cases. Widespread also is the misunderstanding of the term "Pará rubber;" it includes, as far as the technically uninformed are concerned, the idea of a high-class caoutchouc, adapted for all purposes. That Pará rubber cannot be used for all purposes, would only, in rare cases, find credence; the objection that some goods, whether for practical reasons or only for considerations of price, must be produced more or less with the aid of surrogates or fillings, and can then no longer, in accordance with commercial requirements, be designated Pará quality, would often awaken doubts.

IS MATTER ETERNAL?

AN ANSWER FROM THE MODERN PHYSICAL STANDPOINT.

BY F. W. HENKEL, B.A., F.R.A.S.

During the last few years the progress of the electric theory of matter, and the discovery of the universal extension of the phenomena of radio-activity, have led to the conclusion that the time-honored doctrine of the Conservation of Matter (or mass) is, after all, only an approximation, and not an exact truth. Bodies have been considered as made up of material particles separated from one another by non-material spaces of greater or less extent, and there seems good reason to suppose that these spaces are full of a connecting medium to which the name of ether has been given. The material particles, the units of physical and chemical science, are called atoms, and up to recently the atoms were considered to be indivisible units which could not be split up into anything simpler or smaller, and from about seventy different kinds of elementary atoms all the varied forms of matter in the physical world arose. From examination of the various cases of change, especially those of combustion, where it had been thought that there was a disappearance or destruction of matter, it was shown that in all such cases the loss was only apparent. The candle burns, giving out light and heat, and, after a time, is altogether consumed. The materials of which it was composed have disappeared, but their presence may be shown by other means. Burning the candle in a clean bottle full of air, and afterward pouring lime-water into the bottle, we find that the liquid, unaffected by pure air, turns milky, showing the presence of an invisible gaseous body produced by the burning, which possesses different properties from pure air. We may also demonstrate the production of water during this process, and by using caustic soda, or other similar substance, to absorb the products of combustion, we shall find that, so far from a loss of matter, we shall have an apparent gain in weight, this gain being, of course, due to the union of the materials of the candle with an invisible gas (oxygen) present in the air. By careful examination of various cases, and the use of the balance, it was shown that in cases of chemical action, a loss of matter never occurs, but merely a change of state; thus the old philosophic doctrine of the indestructibility of matter was placed on a scientific basis, and it became the fundamental principle of modern chemistry. The work of Rumford, Davy, Joule, Helmholtz, and others showed in a similar manner that energy is, apparently, as indestructible as matter itself, all physical phenomena being accompanied by transformation from one or other of its varied forms into others, either wholly or in part. In the steam-engine the energy of heat becomes converted into mechanical energy; in the galvanic battery the energy of "chemical affinity" becomes the energy of the electric current. In all cases there is an exact numerical relation between the amounts of energy changing from one form into another, and much of the work of physical science during the last half-century has consisted in the determination of what are known as the "mechanical equivalents" of the different kinds of energy. The doctrine of Conservation of Energy asserts that though energy may be transformed, directly or indirectly, from one form into any other, the total amount of it is unalterable. Gain of kinetic energy means loss of potential and *vice versa*, and the amounts thereof are always strictly proportional. "The principle of energy," says Maxwell, "is the one generalized statement which is found to be consistent with fact not in one physical science only, but in all." By its application it has served to the prediction and consequent detection of many hitherto unobserved phenomena, and every advance in science has strengthened our confidence in its truth. The physical world is thus considered to consist of two "realities," matter and energy, in terms of which all its phenomena are to be ultimately explained. These are, however, never found separate; matter without any energy resident in it could not be recognized as such by any of our senses, while energy apart from matter, unless the "ether" be regarded as non-matter, is equally unknown. Matter is regarded as "inert" or passive, energy as active or "living"; both possess the property of conservation—i. e., that the total amount of either can neither be increased nor decreased by any known process. We shall see in the sequel that though it is beyond our power either to create or destroy matter, the latter process seems actually going on to a very small extent in certain cases. We have already stated that ordinary matter, on the atomic theory, is supposed to be built up of small indivisible particles with intervening spaces, and Lord Kelvin's brilliant "vortex-atom" hypothesis of matter supposed that these atoms are simply rotating portions of a perfect and inert fluid which fills all space. In such a fluid, motion once started will continue forever; all the moving parts will be completely distinguished from the rest, and thus the principle of Conservation of Matter follows at once. In spite of its apparent simplicity, the difficulties of the hypothesis are such that it is not now in much favor with physicists, though it is possible that, in a modified form, more may yet be heard of the "hydrodynamical theory."

We come now to the consideration of phenomena bearing on the question of the stability of the atom itself, and which show that the "customary postulate of its indivisibility means no more than that we had not succeeded in discovering a way to decompose it." The discovery of the kathode rays, the X-rays of Röntgen, and the Zeeman effect, give an answer. In a highly-exhausted tube through which an electric discharge is passed, particles charged with negative electrification are shot off with great speed, traveling in straight lines, from the "Kathode" (hence the name Kathode rays), or negative pole, and will render phosphorescent, rubies, alumina, etc., placed in the tube; while if bodies either transparent or opaque be interposed in front of the electrode, sharply-defined shadows will be seen projected on the opposite wall of the tube, "as if they stopped the way for some of the flying molecules." That these particles are not atoms, but something smaller still, is concluded from: (1) The greater length of their path, the kathode rays being able to travel feet, or even yards, while the free path of an ordinary atom is only a small fraction of an inch, even in high vacuum; (2) their speed, which is comparable with that of light itself. From a measurement of the charge carried by these kathode rays, and estimation as to the probable number of particles, Sir J. J. Thomson concludes that the mass of each of these is about 1/1,700 of that of a hydrogen atom, each particle having a "unit" negative charge. To these particles he has given the name of "corpuscles," and, so far as we can see, since the very same kathode rays are found, whatever the nature of the residual gas in the vacuum tube, all the chemical elements seem to be built up of these same identical corpuscles. Thus we are led by a new route toward regarding the different elementary bodies as being all modifications of one and the same substance. Take, say, 1,700 corpuscles and we build up an atom of hydrogen; then sixteen times as many arranged in a somewhat different way, and we get oxygen, and so forth. An uncharged atom may contain a positive nucleus with its full complement of negative corpuscles; a negatively-charged one has one or more negative particles in addition; a positive one has a deficiency of these particles. So far, only negative particles have been isolated; positive charges "appear always associated with atoms of matter," and the nature of positive corpuscles, if such exist, is not yet known. From these considerations there has been built up the electric or "electron" theory of matter, which supposes that all matter may be resolved into an aggregate of electric charges of opposite sign. Not only do we now find evidence of the composite nature of the "atom," that it detaches one or more corpuscles in the way we have indicated; but that it is also undergoing a process of breaking up, more or less rapid. In 1896 M. Becquerel discovered that the salts of the rare metal uranium emit radiations which affect the photographic plate and cause air to become a conductor of electricity, while Mme. Curie found that pitchblende, the mineral from which the uranium salts are obtained, contains other substances far more active than uranium, and to three of these are given the names of radium, polonium, and actinium. Of these, radium is the most active of all. Radium seems chemically somewhat allied to barium; but the chloride and bromide are slightly more crystallizable than the corresponding barium salts. It is constantly and spontaneously emitting three kinds of radiation without any apparent diminution. These are known as the Alpha, Beta, and Gamma rays respectively. The Gamma rays seem to be of similar nature to the Röntgen X-rays; the Beta rays are similar to the kathode rays, to which we have already referred, and they are probably minute corpuscles negatively charged; while the Alpha rays are perhaps positively charged atoms of matter, moving at immense speed. It has been shown that at the temperature of liquid air this emission is neither less nor greater than at the ordinary temperature, and it is not increased by raising the substance to a red heat. "Nothing that can be done to it destroys its radio-activity, nor even appears to increase or diminish it." By bringing a scrap of radium wrapped in an opaque envelope near a diamond in the dark, the latter was found to glow brilliantly, while a "paste" specimen remained inert, which suggests a way of distinguishing between true and imitation jewels. The emanations from uranium are not strong enough to excite this phosphorescence, but by accumulating their influence on a photographic plate for hours or days together, some traces of radio-activity can be obtained. The most sensitive test of all, however, is the power which a radio-active substance possesses of rendering the air conductive, and thus discharging charged bodies. By this means it has been found that many metals, and other substances, possess this power in some small degree—mineral waters, sand, clay, etc.—and the hypothesis has been broached by Le Bon and others that all matter is radio-active. But the most singular thing of all is that these emanations seem to be of a somewhat different nature to the substance from which they are evolved. Rutherford and others have shown that it is probable that the "atomic weight" of the substance thrown off is much less than that of the atoms of the material from which it is projected, and it has been suggested that the matter thrown off may be helium, one of the most inert bodies known. The residual substance from which the radio-activity has been emitted also undergoes remarkable changes. In the case of a radium salt, the residual appears to be "a kind of heavy gas," which slowly diffuses away. It is itself radio-active, as the radium from which it comes, and there seems reason for thinking that its chemical nature is somewhat different. It leaves a radio-active deposit on surfaces over which it has passed, and this deposit is again a different substance. Radium is considered as having a very high atomic weight (225), and the phenomena of its activity as a breaking down of its atoms into simpler systems of lower atomic weights. In this way it may chance that the old idea of the alchemists as to the transmutations of elements may be realized, and in the phenomena of radium we are witnessing the gradual transformation of this element (atomic weight 225) into lead (atomic weight 206) by a series of stages in which helium (atomic weight 4) is thrown off. (All the more active radio-active elements have very high atomic weights.)

Thus we seem led to the conclusion that atoms are not merely complex substances, instead of being simple, as was formerly thought, but that every now and again they break up, and this breaking up is accompanied by the development of a new form of energy which it has been proposed to call "intra-atomic energy." Some have regarded this as a transformation of matter into energy, ordinary matter being simply regarded as a more stable form of energy than the other forms—heat, light, etc.—and by the dissociation of atoms, "the stable form of energy termed matter is changed into more unstable forms—light, heat, electrical action," etc. If this is so, we must regard matter as a transient phenomenon, subject to decay by the action of its own internal energies and motions; but to this we may object: "How, then, is it still in existence, unless it has been created at some comparatively recent date?" Speculations as to the origin of matter, the method of creation of the atoms—whether produced in a manner similar to that in which larger systems have been imagined to come into being, or otherwise—lie, however, far beyond the range of verifiable hypothesis. Here, as everywhere, the relativity and limited character of our knowledge is apparent.

The hard, indivisible atom of the chemist has given place to the system of electrons or corpuscles perhaps in motion round a central nucleus, like the Solar System of Astronomy; but just as the latter is itself only part of a yet larger system, so, too, it may well be that the "corpuscle" is a complex of still smaller units.—English Mechanic and World of Science.

A retrogressive movement in regard to the lighting of trains is proposed by the Prussian Minister for Railways. A few years ago, states the Electrical Review, the defects of gas lighting induced the railway authorities, in emulation of the action taken by other state railways, to make experiments with various systems of electric lighting, particularly in the direction of putting in reading lamps over the carriage seats, as an addition to the gas lamps suspended from the ceilings of the carriages. As the results met with approval, the authorities decided to put in electric

reading lamps in all the D coaches, numbering about 800, the lamps being supplied from plant carried in the luggage vans, with batteries for maintenance of the light when the trains were at a standstill or traveling slowly. This arrangement caused difficulties to arise when the coaches of other German and of foreign railways, which were not similarly equipped, were coupled to the Prussian trains, in which the lamps were often without current owing to the lack of connections. Since that time gas lighting on the incandescent system has made progress, and in view of the increased effects thereby obtained, the Prussian Minister for Railways has now issued an order for the removal of electric reading lamps everywhere, and for the lamps to be used in future for the illumination of sleeping coaches. The only exceptions are the completely electrically lighted trains traveling long distances, as between Hamburg and Berlin, Hamburg and Cologne, etc. No explanation for the discontinuance of the lamps has been given, and it is said that their removal implies a loss of $125,000 represented by the value of the lamps and fittings.

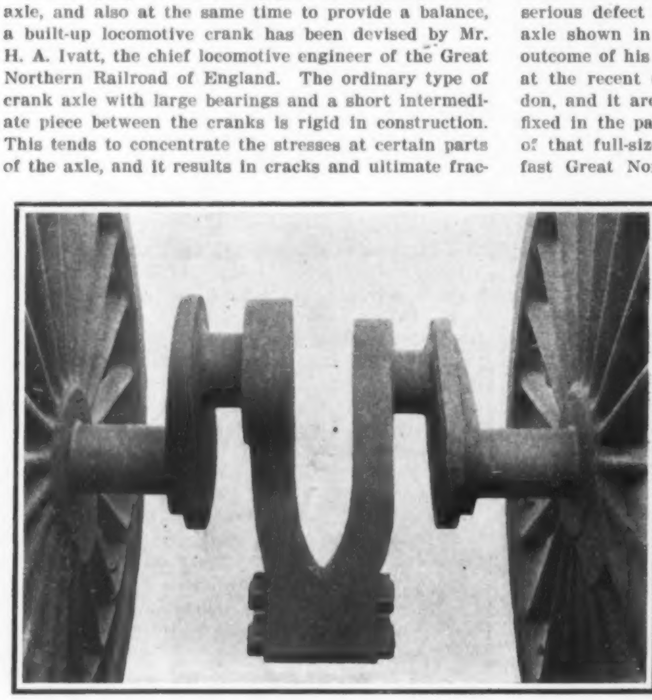
From the report of the Electrification Committee of the New York Railway Club the following brief history is summarized: The first successful trolley installation was made in Richmond in 1888 by Mr. Sprague. For heavier traction the third rail was first used in 1893 at the Chicago World's Fair, and in 1895 this was the distinctive feature of the equipment of the Metropolitan Elevated Railway in Chicago. The multiple-unit system was first put in use in 1898 by the South Side Elevated, of Chicago, and later by the elevated railways of New York city. The first important installation of heavy electric locomotives was by the Baltimore and Ohio in its Baltimore tunnel in 1895; smaller electric locomotives had been previously used for mining and industrial purposes. The Long Island Railway's suburban zone third-rail electric equipment was put in service in 1905. The West Jersey and Sea Shore, between Atlantic City and Philadelphia, was electrified in 1906, and in the same year the New York Central began operating electrically, both by locomotives and by the multiple-unit system, a portion of its electric zone. In 1907 the Erie installed a multiple-unit, high-voltage, single-phase system on its Rochester division; also in 1907 the Spokane and Inland Empire Railroad was put in operation. This is the first railway built for heavy electric service, both freight and passenger, and the current is generated by water power. In 1908 the Grand Trunk Railway electrified the Sarnia tunnel. In 1909 the Cascade tunnel of the Great Northern was electrified on the three-phase system. The Pennsylvania expects to operate electrically its new terminus in New York city during the current year.

IMPROVEMENT IN LOCOMOTIVE MECHANISM.

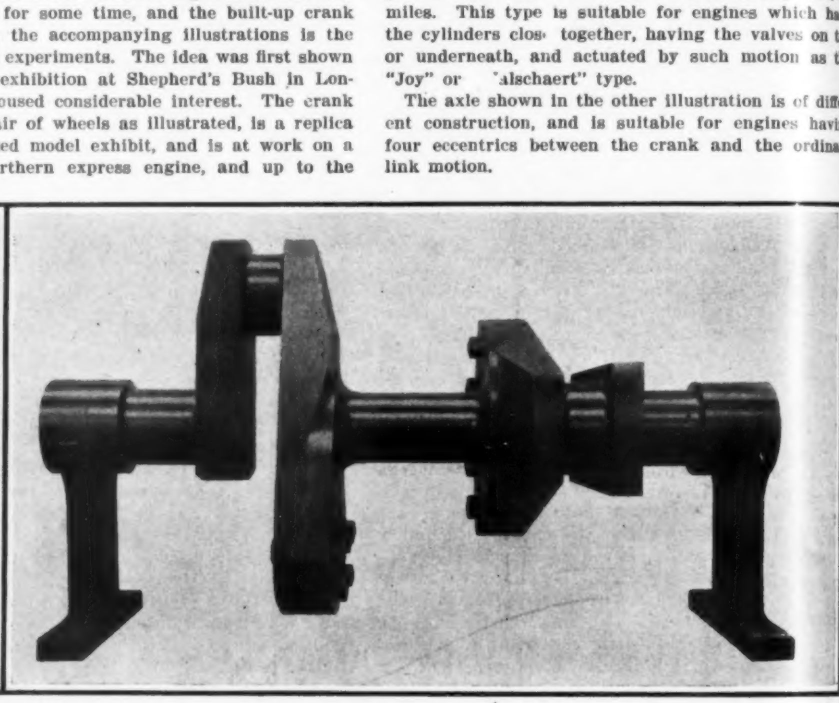
THE "IVATT" FLEXIBLE LOCOMOTIVE CRANK AXLE.

For the purpose of securing greater flexibility in the axle, and also at the same time to provide a balance, a built-up locomotive crank has been devised by Mr. H. A. Ivatt, the chief locomotive engineer of the Great Northern Railroad of England. The ordinary type of crank axle with large bearings and a short intermediate piece between the cranks is rigid in construction. This tends to concentrate the stresses at certain parts of the axle, and it results in cracks and ultimate fracture. Mr. Ivatt has been endeavoring to overcome this serious defect for some time, and the built-up crank axle shown in the accompanying illustrations is the outcome of his experiments. The idea was first shown at the recent exhibition at Shepherd's Bush in London, and it aroused considerable interest. The crank fixed in the pair of wheels as illustrated, is a replica of that full-sized model exhibit, and is at work on a fast Great Northern express engine, and up to the present the locomotive has covered nearly 100,000 miles. This type is suitable for engines which have the cylinders close together, having the valves on top or underneath, and actuated by such motion as the "Joy" or "Walschaert" type.

The axle shown in the other illustration is of different construction, and is suitable for engines having four eccentrics between the crank and the ordinary link motion.



FLEXIBLE LOCOMOTIVE CRANK FOR ENGINES HAVING CYLINDERS CLOSE TOGETHER AND FOR "JOY" OR "WALSCHAERT" MOTION.



FORM OF FLEXIBLE BUILT-UP CRANK AXLE FOR ENGINES HAVING FOUR CYLINDERS BETWEEN CRANK AND ORDINARY LINK MOTION.

THE ELECTRICAL BLAST FURNACE.

In Stahl und Eisen, C. Brisker submits to a careful analysis the figures given in the report of the working of the electrical blast furnace at Domnarfvet in Sweden, calculating in two instances the materials used to produce 100 kilometers of pig-iron, and the distribution of the constituents of these materials among the products of the furnace. In comparing the analysis of the gases at the hearth and at the mouth of the furnace, he finds in the latter a deficiency in carbon, while the ratio of carbon dioxide to carbon monoxide is higher. This is clearly due to the decomposition, in the shaft, of carbon monoxide into carbon dioxide and carbon, the latter being deposited in the ore and afterward aiding in its reduction. The shaft, therefore, the function of which has been by no means clear, is the seat of this important, indeed indispensable, reaction, and, therefore, constitutes an essential part of the furnace; and the cooling of the gases as they leave the hearth is also necessary, since they are thus brought to the temperature most favorable to the progress of this reaction. For comparison, the working of the second charge instanced above, in an ordinary coke furnace, is calculated, and hence the energy expenditure and return in each of the three cases. From the balance sheets it appears that the efficiency of the electric furnace is 51.5 and 50.6 per cent, that of the coke furnace 43.9 per cent, neglecting the "waste gases;" taking these into account, the three figures become respectively 65.3, 66.2, and 76.4 per cent. This is favorable to the electric furnace, when it is remembered that the figures given are results of a small experimental installation, where the losses from radiation, etc., are relatively very great. As moreover iron of much nearer approach to purity can be made in the electric furnace than in the ordinary form, and as fine ore may be used to the extent of 75 per cent of the whole, the electric furnace is already, where electrical energy is cheap, in a position of advantage, and has clearly a future before it.

A NEW TENNESSEE POWER PLANT.

J. G. White & Co., Inc., of New York, have been awarded the contract for the complete engineering and construction of a hydro-electric power plant for the Western Tennessee Power Company.

The dam and hydro-electric power station will be constructed on the Ocoee River at Parksville, Polk County, Tennessee, about twelve miles from Cleveland.

The dam will be of cyclopean concrete and about 780 feet long on the crest. Four hundred and thirty lineal feet of this dam will be of the overflow type, and 350 linear feet will be of the non-overflow type. The overflow portion will be about 110 feet high above mean water stage, having its crest at about an elevation of 825, and will be of the usual ogee section. It will be equipped with suitable flashboards and the necessary temporary and permanent sluices. The non-overflow portion of the dam will be about 13 feet higher than the overflow section, and will be of a special section to accommodate penstock intakes at the top and penstocks passing from the intakes to the turbine below.

The power house will be located on the downstream side of the non-overflow portion of the dam, and will be an integral part of the same. The substructure will be of massive concrete, and will consist mainly of piers and arches below the dam. The turbines will be located at the elevation of the main floor, and will discharge into the tail race under the arches. The superstructure will consist of brick or stone walls with inclosed steel columns. These columns will support the superstructure floors, crane runway, and steel roof trusses. The superstructure floors will be reinforced concrete slabs supported on steel girders and floor beams. The roof slabs will be reinforced concrete supported on steel purlins, and will be provided with suitable roof covering.

The power equipment will consist of four main units of normal rated capacity of 3,000 kilowatts each; one 200-kilowatt exciter unit, the necessary step-up transformers and switching equipment for the control of this apparatus. Each main unit will consist of one tandem horizontal turbine in inclosed case direct connected to a 3-phase, 60-cylinder, waterwheel type, alternating-current generator. Each generator will have mounted on its shaft an exciter, having a capacity sufficient for its excitation.

The miscellaneous equipment will consist of an electrically driven traveling crane, a transformer truck, necessary gates and gate-hoists, water, oil, and air circulating systems, miscellaneous piping, plumbing fittings, pumping apparatus, lighting system, and all other apparatus which is essential for the complete equipment of a first-class station.

A tail race will be excavated for some distance downstream from the power house and will, if found necessary, be separated from the main river channel by timber crib or concrete wall. The shore of the river adjacent to the power house will, if necessary, be protected by means of riprap.

A permanent gravel or macadam road will be constructed from the present highway to the power house entrance. Along the Ocoee River and tributaries thereof, public roads will be relocated at various places where their present grade is below the maximum flow line of the reservoir. New bridges, culverts, etc., will be built where necessary, due to these changes.

The estimated cost is approximately $2,000,000.

THE SAND BLAST AND ITS USES.

THE DEVELOPMENT OF AN AMERICAN INVENTION.

BY RENÉ CHAMPLY.

In 1870 the Philadelphia physicist Tilghmann discovered that a hole could be bored in a block of corundum, at the rate of three inches per hour, by the impact of quartz sand driven by a blast of steam under a pressure of 25 atmospheres. In the following year Dr. Wahl, of the Franklin Institute of Philadelphia, polished a plate of glass with the sand blast. Many years passed before the sand blast came into general use, and it is still absent from many industrial establishments in which it could render valuable service.

The sand blast is employed extensively for polishing, drilling, engraving and decorating lamp globes, bottles, drinking glasses, shop windows and glass objects of every description; for cleaning metals before electroplating or "galvanizing"; for finishing sheet metal and wooden objects, for scouring the hulls of vessels; for removing incrustations from machinery employed in the manufacture of sugar, starch, and malt; for lettering and decorating porcelain, marble, and pottery and stone in general; for giving a dull or "matt" surface to jewelry and bronze, and finally for cutting files and finishing tools of very hard steel.

The sand employed should be very hard and free from earthy particles. It should consist wholly of sharp grains of nearly pure silica, varying in fineness from No. 1 to No. 3 of the emery scale, according to the character of the work. For some purposes pellets of hard steel of the size of a small pinhead may be used instead of sand. This steel shot produces no dust, works rapidly, provides a very smooth surface, free from pinholes, and is very durable.

The blast of air or steam takes up the sand either by aspiration or by direct impact. Experience has proved that the velocity of efflux of sand impelled by compressed air or other fluid cannot exceed a limit, which varies with the fluid but is independent of the pressure. For example, a greater velocity is produced by steam than by compressed air. For most purposes, however, air at pressures ranging from 12 to 30 pounds per square inch (above atmospheric pressure) works satisfactorily, and steam is employed only for special work, such as cutting files.

The sand blast may be either stationary or portable. The portable machine is used in cleaning and scouring objects too large to be easily transported. The apparatus consists of a mixing chamber connected on one side with an air reservoir and compressing pump, and on the other with an India rubber tube provided with a fine nozzle, by means of which the blast of air and sand is directed upon the object. As the air of the operating room is made irrespirable by the clouds of dust produced, the head of the attendant is inclosed in an airtight helmet, into which pure air is forced through a tube. The sand dispersed by the blast settles on the floor. It is collected, sifted and returned to the mixing chamber, and can be used many times.

In the Tilghmann machine the stream of compressed air is projected upon the sand and carries it away di-

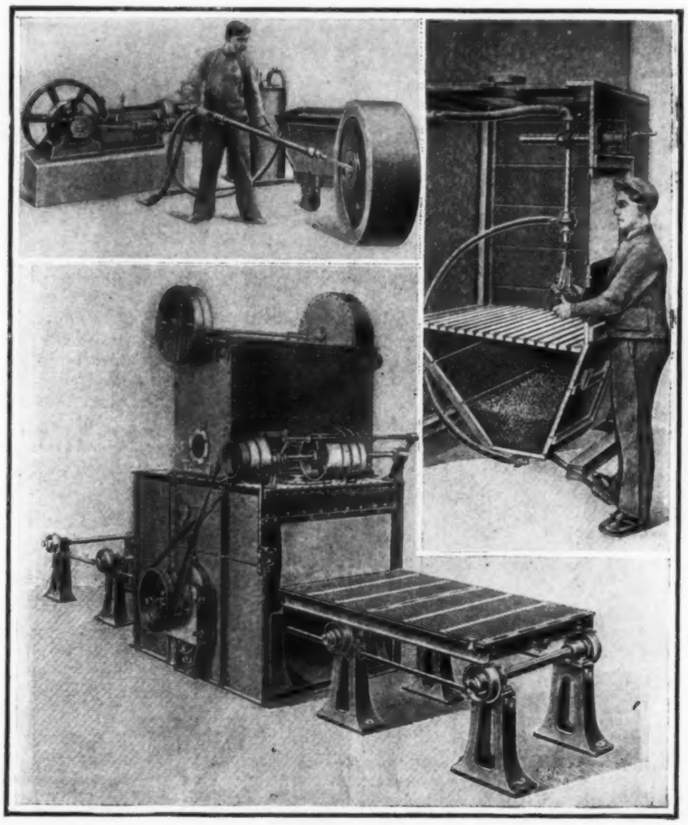


Fig. 4.—(above) Scouring Large Objects with a Portable Sand Blast.
Fig. 5.—(right hand) Cleaning Small Objects in a Closed Chamber.
Fig. 6.—(below) Automatic Machine with Reciprocating Table.

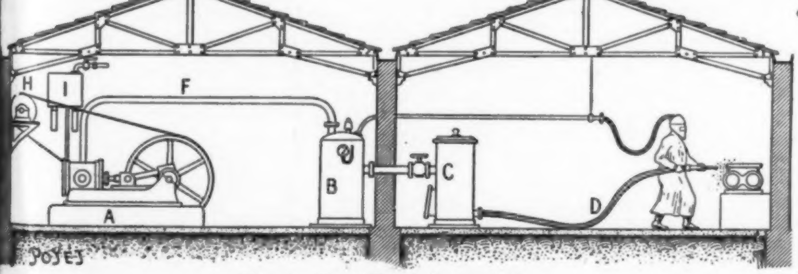


Fig. 1.—Sand Blast Apparatus.

A, compressing pump; H, power transmission; I, water-cooling device; B, reservoir of compressed air; F, air pipe; C, mixing chamber; D, flexible sand blast tube. A small pipe connects the workman's helmet with the compressed air reservoir.

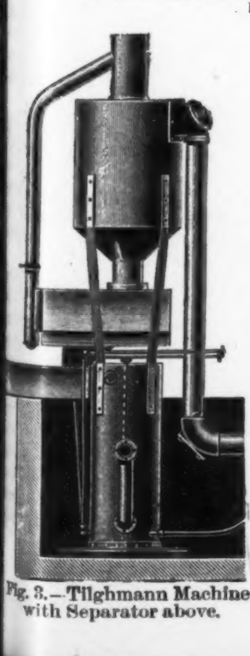


Fig. 3.—Tilghmann Machine with Separator above.

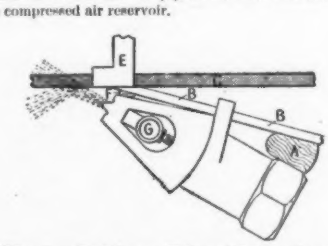


Fig. 9.—Cutting a File with the Steam Sand Blast.

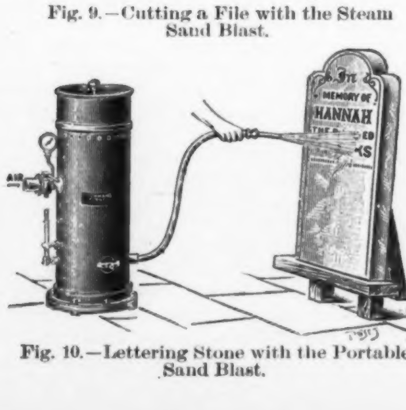


Fig. 10.—Lettering Stone with the Portable Sand Blast.

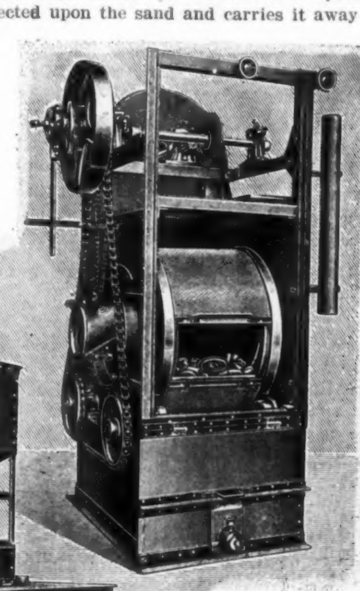


Fig. 7.—Machine with Rotating Drum.

Fig. 8.—Machine with Turntable.

Fig. 2.—Helmet worn by Workers with the Sand Blast.

rectly. These machines can also use the fine steel shot described above. The air reservoir and mixing chamber are placed in the cellar of the building, whence the blast of air and sand is forced through a pipe to the operating room above. The sand, after being used, is collected and sifted by a separator and a sieve at the top of the apparatus, whence it falls through a chute.

The sand blast machines of an establishment at Durlach, Germany, act by aspiration. Two India rubber tubes connect the aspirating pipe with the reservoir of compressed air and a vessel of sand below. The aspiration is so energetic that the sand is drawn up and projected forcibly upon the object.

Several devices, which are here illustrated, have been invented for the purpose of protecting the workmen from dust, without using the unreliable and unsanitary helmet. In one apparatus the attendant stands outside the operating chamber, into which he introduces the objects through a slit, and watches the operation through a glass window. There is also an automatic apparatus, in which the objects are placed in a rotating drum, or on a rotating or reciprocating table, which carries them into a closed chamber in which the sand blast is produced, so that no sand is scattered outside. The steam sand blast operates by aspiration of a mixture of sand and water, which is pumped through a pipe which enters the projecting nozzle, very near its mouth.

When the sand blast is employed for lettering or decorating, the design is drawn on paper, which is pasted on the object. The parts which are to be exposed to the sand blast are then cut away with a knife. The sand blast is applied to the entire surface, but it does not attack the parts protected by the paper, while the intervening portions are cut out deeply, even in the hardest stone, with a sharpness and a polish which cannot be obtained with the burin. It has been conjectured that the sand blast was employed in cutting the inscriptions on Egyptian obelisks, for these are free from the irregularities which the burin would inevitably have produced, by detaching small crystals from the granitic stone.—La Nature.

THE INVENTION OF "PROTAL."*

A NEW PRODUCT FOR USE IN THE ARTS.

BY DR. F. G. WIECHMANN.

On account of the present great activity in the rubber industry, owing to the enormously increased demand for rubber, the presentation of a new substance which possesses a number of valuable qualities, and which can be used in many of the arts and industries where rubber and similar materials are now employed, would seem to be of timely interest.

When, in 1844, Goodyear announced to the world the discovery he had made in 1839, that he had succeeded, by the use of sulphur and the influence of heat, in producing plastic, semi-plastic and hard bodies of rubber suitable for use in the arts, a new industry was born. Prior to such time there were few uses for rubber. Since that time the business has grown until to-day it has become one of the most important of industries.

Statistics show that the actual capital invested in the rubber trade in North America is approximately $150,000,000 at the present time, and the industry employs not less than 100,000 men. The rubber industry has been the parent of other industries, among which may be mentioned that of the manufacture of bicycles and automobiles. The use to which rubber compounds may be put in the arts has increased to such an extent that to-day the production of rubber does not meet the demand.

Within the last year the trade has seen rubber advanced greatly in price. The average price for Upriver, Fine, Pará rubber was, in 1907, $1.09¼; 1908, $0.93½; 1909, $1.59¾.

The range of prices of this grade of rubber was, in 1908, low, $0.70 in March; 1908, high, $1.30 in November; 1909, low, $1.20 in January; 1909, high, $2.15 in September.

In 1910 the figures quoted were: January 1st, $1.64; February 1st, $1.80; March 1st, $2; April 1st, $2.53; May 1st, $2.77.

For these figures I am indebted to the courtesy of Mr. Hawthorne Hill, associate editor of the India Rubber World.

This advance in price, as in other industries, has made the use of rubber for purposes which were possible at from 80 cents to $1 a pound, impossible; or, in other words, commercially impracticable.

The continued and steady advance in the price of rubber has naturally directed the attention of technical chemists to the production of substitutes for it, but, up to the present time, it would seem that no satisfactory substitute for rubber has been discovered. It is true that valuable substances have been produced, such, for instance, as celluloid, which have taken the place of rubber for certain uses, and that many other materials have been created, for instance, shellac compounds, which have also been used in place of hard rubber for certain purposes, but, as before stated, it is believed that no substance or compound has been produced which may be used in the same manner and for all of the purposes for which hard rubber has heretofore been employed.

The shellac compounds mentioned, as well as all other compounds having the same characteristics, have, in a measure, been found unsatisfactory, owing to the fact that their composition is based upon the use of a body of some kind and a binder. The only binder in this class of compounds which experience has proved to be of any particular value has always consisted of a resin, but the principal objection to resinous compounds is that they are oxidizable, that is to say, the resin is subject to an oxidizing process which destroys the value of the binder. In other words, the artificial resinous substitutes for hard rubber exaggerate the one great objection to the use of hard rubber in the arts; or every one familiar with the rubber industry, or the uses of rubber, is aware of the fact that if hard rubber is exposed to the action of the atmosphere, or to the action of a body which will set free oxygen, deterioration of the rubber will take place more or less rapidly.

The only situation in which hard rubber may be used without incurring such deterioration is where it is so placed that it is not exposed in any way to the action of oxygen.

One of the reasons why a satisfactory substitute for rubber has not been found before is possibly owing to cognizance not having been taken of the fact that certain products of nature may be chemically acted upon to convert them into bodies which may be treated as is the case with rubber, and which, when treated, possess within themselves qualities, such, for instance, as strength, resiliency, non-oxidizability, which render them permanent compounds.

It now gives me great pleasure to announce that within the past three years I have succeeded in producing compounds, and to present to you samples of various modifications thereof, which possess many of the physical characteristics of rubber compounds, and which present the additional advantage that they are entirely free from the one principal objectionable feature of rubber, that is to say, they are not prone to oxidation.

Before entering into a description of this material, I would recall to your attention the splendid work with which I suppose you are familiar, which has been carried on in this country and in Germany for the past ten years, relating to proteids and proteid compounds—at present the dark continent of chemistry.

The product which I here present to you, is based upon the employment of a natural proteid. It may cause some astonishment when I state that the combination of two protein bodies results in the production of a third body which is dissimilar in physical appearance or characteristics from either of the original proteids. The chemistry of proteids and of the reaction of proteids upon proteids alone, or in the presence of catalytic agents, is difficult to express, either in language or chemical symbols, and we, therefore, have to depend, to a certain extent, for the evidences of change and reaction upon the physical appearance and properties of the bodies, due to the bringing together of these substances.

The base of the material to which I direct your attention is, as before stated, a product of nature, and it occurs in nature in a great many different forms. I refer to vegetable-albumin. It will not be necessary for me to state in detail to you who are familiar with organic chemistry the numerous sources from which the vegetable-albumin may be derived.

But, while this vegetable-albumin can be derived from a great variety of sources, and while it is to be understood that under this generic term—vegetable-albumin—there are included many substances, among them vegetable ivory, the vegetable caseins, the glutens, hemi-celluloses, reserve-celluloses, horny albumins, etc., the form in which the vegetable-albumin seems specially well adapted for the production of this new material is that occurring as the seed of certain palms, in which the vegetable-albumin plays the rôle a reserve cellulose.

These seeds possess a hard, horny endosperm, and are found principally among the monocotyledons, especially in palms, liliacees, iridacees and in plants of a kindred kind.

The seeds of some dicotyledons also contain vegetable-albumin in the form of reserve celluloses, and it is generally found that where such reserve celluloses predominate, there is little or no starch, these two substances seeming to be equally capable of sustaining the life of the germinating plant, the purpose which Nature has destined them to serve.

One variety of palm, the *Phytelephas macrocarpa*, which grows especially in South America, produces hard, fine-grained seeds—the so-called Tagua nuts; these, for almost a century, have been used and valued for the manufacture of buttons and sundry other small objects produced by the turner's art.

The nuts are sent up here from South America, and split up into discs. The button turner takes these discs, presses them against his very rapidly revolving knife, and all that remains is waste in their industry, known as "ring waste." This material at the present time costs about $170 to $175 a ton, and the waste of this material is approximately 70 per cent. Up to this time most of it has been burned under the boilers just to get rid of it; it has a low fuel value.

Similar seeds, or nuts, as they are commonly called, are furnished also by other varieties of palms, for instance, by the *Phytelephas microcarpa*, and also by the cocoa palm; the seeds produced by the latter are generally termed Corozo nuts.

The vegetable-albumin which forms so large a percentage of this material is, by Nature, intended to serve as food for the young plant embryo before the same is able to procure and prepare its own nourishment.

Originally, this vegetable-albumin occurs as a liquid which is sometimes used as a drink by the natives of the country in which the palms grow, but at a later period of its development this material, after having passed through an intermediate, pulplike condition, solidifies, and turns into the hardest form of albumin known.

On germination of the young plant, however, it seems that enzymes or ferments appear, which again soften the hard mass and reduce it to a pabulum, fit and ready for assimilation by the new and growing plant.

Now, given an albuminous base of vegetable-albumin, it is possible, by adding to such base an animal albumin, together with any suitable solvent, to produce a compound which in physical appearance is different from either of the two bodies entering into the combination; to produce a compound which, so far as I am aware (and my experiments have been extended over a period of years) cannot be separated by any known chemical process into its original elements; a body whose physical characteristics are different in that it has a tensile strength, an electrical resistance, and a solubility different from that of either of the bodies incorporated.

This material may be loaded with any of the materials commonly used in loading rubber. Certainly more than eighty different substances have been used by myself for this purpose, and by the addition of elastic bodies, resinous or non-resinous, including rubber, this material may be employed to take the place of rubber in a large number of industries.

For this material, the name Protal was suggested, the first four letters of the word being derived from the word "protein," the last two from the word "albumin."

In the further development of Protal, this name may, however, be said to have taken on a different, a wider significance, and may be regarded as indicative of the numerous, the Protean forms in which this material is obtainable.

To summarize: Protal is the name of a new industrial plastic, the base of which is derived from the plant world, as the base of rubber is derived from the plant world, and which may be subjected to such treatment and processes as serve to convert it into a plastic, semi-solid, or solid mass, having characteristics which permit such mass to be molded, cast, pressed, or otherwise formed into shapes, and pos-

* Abstract of a paper read before the American Institute of Chemical Engineers, Niagara Falls, on June 22nd, 1910.

sessed of such properties as to permit its use in a number of the arts and industries.

To produce the new plastic, the vegetable-albumin is treated by one or more substances, which, it is believed, convert it into a new substance, new not only in its physical characteristics, but in its chemical characteristics. By this expression I would have it understood that the resulting material is neither vegetable-albumin nor the material with which it is treated, but a new material from which the original components may not be recovered unchanged, at least not by any process known to me.

When first produced, Protal is perfectly plastic, but it soon acquires the hardness of stone; on re-warming, however, it resumes its plasticity sufficiently to permit of its being molded under pressure in any shape or form. In molding, it takes sharp and clear impressions. Molding articles from Protal can be done in either of the following ways:

1. The freshly made mix can be pressed directly, without the application of heat, into the desired form and the article so fashioned subsequently dried. If this process is followed, proper allowance must be made in devising the die or form used for the shrinkage which occurs in drying.

2. The freshly made mix can be pressed without the application of heat into any convenient primary form—such as slabs, plates, discs, rods, etc., and these dried. After being dried, the desired articles can be pressed from such primary forms under the application of heat. If this process is followed, there need be no allowance made for shrinkage in devising the final die or mold to be used.

3. The freshly made mix is flaked or shredded and ground into a powder of any desired degree of fineness and this powder dried.

From such dry powder any desired article can, of course, be pressed or molded with the application of heat. The drying in this process and in those before mentioned is best conducted in a simple form of vacuum drier, or by the aid of a heated air current.

Protal is odorless, resilient; it can be cut, sawed, filed, polished, tapped and countersunk, like hard rubber and hard wood. It can be colored by dyes and all pigments can be incorporated with it. It is non-explosive, and when heated in a Bunsen flame it does not burn actively, but only chars and smoulders.

In one series of experiments an electric current was passed through a German silver wire imbedded in Protal, until the wire fused at 7½ amperes—the Protal showed no signs whatever of burning. By the incorporation of certain chemicals, the heat resisting qualities of Protal can be materially increased even beyond this point.

Protal in some of its forms is a good electric insulator.

One hundred and eighty-four Protal compounds which were tested for their dielectric strength were found to range in their mean effective dielectric strength from a minimum of 512 volts per millimeter up to 10,276 volts per millimeter. Some of the values obtained were 6,693, 7,520, 8,740 and 9,567; the maximum value, as already stated, being 10,276 volts per millimeter.

In tensile strength, pure Protal compounds range from 1,000 pounds to 2,110 pounds per square inch. Of ten Protal compounds which were submitted to compression tests, three, under a load of 100,000 pounds, showed no compression whatever; two a compression of 8.3 per cent; one a compression of 10 per cent and four a compression of 16.7 per cent. These tests were made in the chemical and physical laboratories of Dr. C. F. McKenna, New York city.

As before stated, it would exceed the limits of this paper to take up and discuss the properties and qualities of all of the many Protal compounds prepared.

Some compounds made, proved to be of value for abrasive and polishing purposes; wheels of this kind were run at a speed of 4,000 revolutions per minute, cutting iron, steel, brass, etc., with ease, and did not rupture when tapped while running.

Protal compounds with asbestos, shellac and the resins proved to be plastic and moldable, and some of these compounds possess the remarkable quality of hardening to stone on immersion in water.

Compounds of Protal with linseed oil, cork flour and various pigments incorporated therewith, proved of a nature well adapted to the manufacture of oilcloth, etc.

The most interesting compounds of all, however, are perhaps those of Protal with rubber, rubber fluxes and a variety of so-called rubber substitutes. These compounds, according to the relative percentages of their ingredients, possess a wide range of hardness and flexibility; this class of Protal compounds may be produced either soft, semi-soft or hard, their quality in this respect being due to the proper choice of loading materials and the judicious application of varying degrees of heat and pressure.

Any and all colors and pigments may be incorporated with Protal compounds, and they are also capable of being dyed with aniline colors; they may be machined, tooled, tapped and buffed, like hard rubber and celluloid. All are resistant to the ordinary conditions of every-day use and wear, but one important limitation to the usefulness of some of these Protal compounds is their susceptibility to the solvent influence of water and of other chemical reagents. This objection may be largely removed by subjecting this material to the action of a coating body or bodies, which fill the molecular spaces existing in the structure of the material, for instance, by the use of formaldehyde or resins. In case use is made of resins it would appear that the material produced must necessarily be open to the same objections as were stated by me in referring to the shellac substitutes for rubber, that is to say, the oxidization of the resins. And this is true; where resins are used there is this objection. I am glad, however, to be in a position to state to you that, as it has been found possible entirely to dispense with the use of resins, this objection has been entirely overcome.*

You will probably all remember the most interesting papers which were read last year before the American Chemical Society and other scientific institutions by Dr. L. H. Baekeland, when he announced his remarkable discovery, his method of producing condensation products of phenol and formaldehyde. Immediately upon Dr. Baekeland's announcement it at once became apparent to me that such a condensation product of phenol and formaldehyde, in the form announced by Dr. Baekeland, was the material which I had so long sought and which would, when used in connection with Protal, produce a compound capable of manipulation like rubber, and yet be entirely free from all the objections which had been urged to the use of a resinous body, because, as you know, a condensation product of phenol and formaldehyde is not a resin, as this term is generally understood—it does not saponify at all. This new material is known as protal-bakelite.

One form in which Dr. Baekeland produces bakelite is transparent. It partakes very much of the nature of amber, and lends itself beautifully to the manufacture of jewelry and pipe-stems. It picks up paper and has essentially the properties of amber. To produce protal-bakelite, these two substances are intermingled most intimately.

There may be skeptics when I announce my belief of definite reactions taking place between the individual components which form this material, reactions between a protein body and the condensation product of phenol and formaldehyde. In proof, I offer the resultant materials. You certainly will recognize that the materials presented to you are entirely different from the elements entering into these products; samples of these individual components are herewith also submitted.

The reactions between the protal and the condensation product of phenol and formaldehyde take place in the presence of heat, or of heat and pressure, and the product evidences that such reactions, be they chemical, physical, or chemical and physical both, have taken place.

Protal-bakelite, like protal, may be combined with a large variety of substances, that is to say, combined in the physical sense. A large variety of substances may be added, as loading material, the material used as a load depending entirely upon the use to which the final product is to be put; as for instance, in the production of an insulator the best results can be obtained by the introduction of mica, asbestos, or both.

Where it is desired to increase the tensile strength of the product for use in situations where it is to stand very severe mechanical blows constantly applied, as for instance in pump valves, I have found it desirable to add asbestos or any other fibrous materials, which are not readily decomposed by gases, acids, steam, oils, etc.

Where the material is to be used for molding operations, there may be added to the protal-bakelite any material which will increase its primary plastic characteristics, as for instance, paper pulp, wood flour, cellulose, or preferably, non-structural cellulose, these materials allowing very sharp impressions to be given to the material.

Protal-bakelite compounds, in consequence of the great resistance which they exhibit toward nearly all chemical solvents, the high dielectric strength which many of these compounds possess, their hardness and ability to take a high degree of polish, mark them as particularly well adapted for many purposes and uses in which hard rubber and hard rubber compounds are at present almost exclusively employed.

Protal-bakelite may be produced in three forms: (1) A plastic form, which may be readily molded; (2) a semi-plastic form capable of a certain amount of molding or impression, and (3) a hard, permanent form. The first two forms are susceptible to the action of heat and steam, and of certain chemical reagents which would tend to change their form and destroy them.

In its final form, that is, after subjection to the final treatment, bakelizing, i. e., heating under a pressure sufficient to prevent dissociation and resulting sponginess, the material is not susceptible to the action of the atmosphere, steam, oils, gases, acids, etc.

Objects can be produced directly by filling the powder into the molds and subjecting it to the proper temperature and hydraulic pressure. On the other hand, the powder can be pressed into a preliminary form by applying hydraulic pressure at a low temperature. Placed into a mold and using a higher temperature, and, of course, again hydraulic pressure, the material can then be shaped into any form desired. There is still another form of our material known as bakelite-paper, or as protal-bakelite paper, in which the material is rolled out into very thin sheets, like paper, and which can then be placed in molds and pressed.

Without going into details as to manipulation, I would state that this material may be rolled, pressed, molded, shaped or otherwise manipulated, as is the case with hard rubber; that it takes a high polish; that it will meet the requirements of articles produced from hard rubber, and, furthermore, that this product is not open to the most serious objection attaching to hard rubber, i. e., it is not subject to oxidation and to all that that implies.

It may now be of interest to give a brief survey of some of the properties of protal-bakelite compounds, considering first of all such compounds which consist of 50 per cent each of these components.

The specific gravity of these compounds is practically 1.36; they exhibit a tensile strength of 2,010 pounds per square inch, and a crushing strength of over 60,000 pounds per square inch. On immersion in water, steam, machine oil, cylinder oil, acetone, alcohol, sulphuric acid, acetic acid, turpentine, benzine and dilute solutions of sodium carbonate and ammonium hydrate, this material displays absolute indifference to all of these reagents. A plate of the above composition was exposed in the cabinet of a high power medical electric machine generating between 300,000 and 400,000 volts, for over three months, and was not attacked by the ozone, or whatever the oxidizing components of the atmosphere in the cabinet may have been. Hard rubber, under these conditions, is very seriously affected. Subjecting protal-bakelite to actively boiling water for some hours produces no effect beyond a lightening in color; immersed in water at ordinary temperatures for months produces no deterioration whatsoever.

It thus appears that protal-bakelite possesses the following advantages over hard rubber. It does not soften by heat, as rubber does—in fact, protal-bakelite in the making may be said to be frozen by fire; it is not attacked by oils, grease, or the fats; it is not attacked by oxygen and ozone, and, as it contains no sulphur, the possibility of formation of sulphuric acid, a very serious matter indeed in the construction of delicate electrical measuring instruments, is entirely obviated.

As far as the dielectric strength of pure protal-bakelite compounds of varying percentage-composition is concerned, tests of record made by the Electrical Testing Laboratories, New York city, have shown, among many others, the following values:

Protal, per cent.	Bakelite, per cent.	Volts, per mil.	Volts, per m.m.
90	10	125	4,921
80	20	145	5,709
70	30	160	6,299
60	40	227	8,937
50	50	230	9,055

It should be remarked that these tests were performed on samples as produced, and without having subjected the same to subsequent baking; such baking would undoubtedly have materially raised these values. Concerning the tensile strength of pure protal-bakelite compounds, this was found to range from 1,190 to 2,170 pounds per square inch. Among compounds of protal-bakelite with other ingredients, some possess a tensile strength of over 3,000 pounds per square inch, and from the many tests of record of their dielectric strength made by the Electrical Testing Laboratories, the following may be quoted:

	Volts, per mil.	Volts, per m.m.		Volts, per mil.	Volts, per m.m.
1	227	8,937	8	252	9,921
2	227	8,937	9	330	12,992
3	232	9,134	10	380	14,961
4	235	9,252	11	450	17,716
5	248	9,764	12	550	21,653
6	252	9,921	13	660	25,984
7	252	9,921			

USES.

After what has been said, it would appear unnecessary, even if it were not practically impossible, to enumerate all of the many uses to which these new products can be put in the arts, and it must, therefore, suffice to indicate but a limited number of

* These have been published in the Scientific American Supplement.

articles which can be advantageously made therefrom.

To this end it would seem desirable to adopt some rough method of classification based upon the special physical demands made upon these compounds in the various industries in which the compounds will be used.

Considering, then, first such articles wherein tensile strength, toughness and resistance to the ordinary conditions of every-day wear and tear are the qualities called for, mention may be made of: Bodkins, buttons, checkers, chessmen, children's building blocks, cup plates, dominoes, door knobs, furniture castors, key tags, molding of all kinds, panels, pencil holders, phonograph records—both disc and cylindrical—piano keys, picture frames, roller skate wheels, rulers, shoe arches, shoe box tips, shoe trees, spools, table tops, telephone receivers and transmitters, thread drawing bobbins, etc.

Among the numerous articles in which, in addition to the qualities above mentioned, resistance to the influence of hot and cold water, steam and chemical reagents is demanded, there may be named: Battery jars, bushings, fountain pens, gaskets, grips for bicycles, guns and pistols, handles for umbrellas, guns, cutlery of all kinds, inclusive of razors, dental and surgical instruments, lags, pump valves, rods, slabs, stocks of guns and pistols, shingles, trays—photographic and other kinds—tiles, tubes, washers, wheels, abrasive and polishing, etc.

Owing to the great range of dielectric strength which protal-bakelite compounds of different composition possess, they are of special value for electric insulation of every kind and description. Among articles used for this purpose there may be mentioned: High tension transmission insulators, high grade electrical measuring instruments, ignition coils, linings for terminal boxes, magnet cores, magnetos, plates, strain insulators for trolley service, switchboards, etc.

Where considerable flexibility is demanded of the material, other grades of protal compounds must be employed; from these there can be made: Automobile tires, bicycle tires, diaphragms, discs, doormats and runners, heels and soles, horseshoe pads, interlocking tiles, plumbers' force cups, valves—soft and semi-hard—weather strips, etc.

Among the recent publications of the U. S. National Museum are two papers on fish. The first of these, No. 1744, is "A Review of the Flounders Belonging to the Genus Pleuronichthys," by Edwin Chapin Starks and William Francis Thompson, of Stanford University, California, and is an extract from the current volume of the Proceedings. In it are described seven species of flounders, of which number six are from American waters, and of these, two are new to science. The types of these new species have been deposited in the collection of the U. S. National Museum. The second paper is a brief "Comparison of the Chub-Mackerels of the Atlantic and Pacific Oceans," by Barton Warren Evermann and William Converse Kendall, of the U. S. Bureau of Fisheries. The measurements of eight specimens from the Atlantic Ocean and of thirteen from the Pacific Ocean are contrasted, showing a well-marked difference between the chub-mackerels from these oceans that is of specific value. The authors conclude that the Atlantic form should, therefore, retain the name *Scomber colias Gmelin* and the Pacific form the name *Scomber japonicus Huttuyn.* This paper is likewise an extract from the current volume of the Proceedings.

ENGINEERING NOTES.

The Cambridge Scientific Instrument Company have introduced a modified form of the impact testing machine originally devised by Stanton. The hammer is attached to the free end of a hinged lever, and is raised by one end of a rod resting on a roller, which is capable of lateral movement so that the lift can be varied. The other end of the rod is driven by a crank so that the free end has an elliptical motion, raising the hammer and then allowing it to fall. One end of the specimen is held on a knife-edge by means of a spring, and the other end is held in a chuck flexibly connected by a universal joint to the driving gear, which is fitted with an escapement. The driving gear is arranged to turn the specimen through 180 deg. between two consecutive blows. When the specimen breaks, the fall of the hammer opens the electrical circuit in the motor driving the machine. A counter is provided to determine the total number of blows struck.

The Nicholas Railway, that connects St. Petersburg and Moscow, has long been incapable of dealing adequately with the growing stream of traffic. The Moscow, Windau, and Rybinsk Company, which is probably the best managed company in Russia, has just made an important proposal to the government with a view to relieving the congested traffic of the Nicholas Railway. This proposal consists of a project for laying down a line of railway from Valdai on the Rybinsk and Pleskov railway in a northwest direction to Narva, the little fortified town on the Baltic, 81 miles west southwest of St. Petersburg. The line would be 220 miles in length, and it would be laid from Valdai to Krestzy, and thence past the northern end of Lake Ilmen to Novgorod, Luga, and Narva. At Luga the new line would cross the railway that connects St. Petersburg and Berlin. While the projected railway would be of immense service to Russia's export trade, it would be of even more importance from a military and strategic aspect. Immense forces of infantry, cavalry, and artillery are concentrated near Novgorod and Luga, and these forces could be conveyed by the projected railway to the Baltic in a few hours.

A problem arising from the development of reinforced concrete construction is represented by the conflict of demand and supply in relation to the diameter of bars and rods for the purpose of reinforcement. In order, says the Builder, to provide the requisite area of steel without wasteful excess, designers often feel bound to specify diameters which are not those of the stock sizes adopted by rolling mills, and it is by no means unusual for specifications to demand a considerable variety of diameters, as well as a small quantity of bars of each diameter. Some designers of reinforced concrete work may not recognize the fact that special demands of the kind are sure to cause delay and additional expense. From a paragraph in the Iron Age it seems that a good many orders for reinforcing bars are being declined by American rolling mills because of the inconvenience attaching to the production of special sizes during a period when the plant is fully occupied by rolling standard sections. As the same difficulty applies in England, it is very desirable that standard diameters should be adopted as far as possible. But as bars varying in diameter by sixteenths of an inch are almost indispensable for economical construction, we hope that the leading steel manufacturers will take that fact into account by suitable additions to the range of their standard sizes.

ELECTRICAL NOTES.

It should be remembered that the terminal ends of cables are often responsible for low insulation readings. All hygroscopic tapes should be trimmed well back from metal lugs, which themselves should be disconnected entirely from the switchboard panels at each end, otherwise most misleading results are likely to be obtained. In damp weather the ends should be warmed to drive off all moisture. This remark applies equally to the test set itself, and to the testing leads, which latter should always be themselves tested for insulation resistance and continuity, both before and after all cable tests.

The operation of electric light and power systems is often interrupted by rats and cats coming into contact with the wires and establishing short circuits. The first instance of similar disturbance caused by an insect recently occurred in California on a line which serves a number of cities and carries alternating current at a tension of 52,000 volts. This line is protected by a number of lightning arresters each of which contains a ground wire separated from the line wire by a short air gap, over which sparks pass when the tension becomes excessive. A large insect entered one of these air spaces, diminishing the gap to such an extent that sparks passed and an electric arc was formed which discharged the whole system.

Graphite and carborundum furnaces require variations of voltage of supply to allow for change of resistance as the temperature of the furnace varies. A new method, introduced by an electrical firm, for a 1,600-kilowatt, 25-alternating, single-phase transformer, erected at the Acheson Graphite Company's works at Niagara, has recently been described in the columns of a contemporary. The transformer has a primary winding for 2,200 volts, while the secondary pressure can be varied from 40 to 200 volts—this range being obtained by taps on the primary and by a series parallel connection of the secondary. At 200 volts the current is 800 amperes, and at 40 volts it is 4,000 amperes, there being a smooth regulation between similar to that given by an induction regulator, but at better efficiency and power factor. A motor is employed to operate the 4,000-ampere switch. A dial switch disconnects the successive sections of the primary winding, and a compensator connects successively across two adjacent taps of the transformer, etc. All the switches, etc., are operated in proper sequence as described in the article, a diagram of connections being given to show how the various parts are connected up.

A German company has patented a process of regenerating carbon filament electric lamps when the glass bulb has become blackened by a deposit of carbon and the filament shows weak spots, but is not actually broken. The point of the bulb is broken off in order to admit the air, and a tube, by means of which the bulb can again be exhausted, is welded on. The lamp is heated in a large flame until the deposit of carbon has been entirely burned off. The air is then drawn from the bulb and replaced by a suitable gaseous hydrocarbon, and the filament is heated to incandescence by an electric current. This is the operation of "feeding" which is already used in the manufacture of new lamps. Both the new and the old filament have weak or thin spots. When the filament is heated by an electric current in a gaseous hydrocarbon, the gas is decomposed and carbon is deposited on the filament, most abundantly on the thin parts, because these oppose most resistance to the current and are consequently heated most strongly. Hence the thickness of the filament not only increases, but becomes more uniform. The operation is continued until the filament has acquired a uniform thickness, exactly equal to that of a new filament. All that now remains to be done is to exhaust the bulb and melt off the auxiliary tube. The cost of regeneration by this method is five cents per lamp, while a new lamp costs nine cents. The process is especially advantageous for electric companies which supply lamps to their customers without charge and which are annually compelled to replace large numbers of lamps.

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TABLE OF CONTENTS.

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be dis-
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armed
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